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RADIOLOGICAL EXPERIENCES IN TRUE STRANGULATING OBSTRUCTIONS[1]

by

J. Frimann-Dahl.

The importance of the roentgen examination in acute abdominal diseases, especially in cases of obstruction, is generally accepted. It is emphasized here that adequate diagnostic conclusions depend upon a thorough knowledge of the findings in a great variety of acute abdominal conditions. A single group of disorders should not be selected for examination. The diagnostic possibilities are so manifold that misinterpretations are likely if the various diseases and differentiations are not surveyed in relation to each other. Such a proposition is quite natural to the surgeons and should evidently be of the same validity to the radiologists. Along these lines it is stressed that in a great many cases we have to follow and observe the patient by repeated examinations. A conclusive diagnosis may be impossible based on one examination only, while a comparison of the findings on several occasions often greatly facilitates the establishment of the diagnosis. Moreover, such examinations may give sufficient means for a prognostic evaluation, by determining an increase or decrease of the signs. On the other hand, the radiologist must be careful not to prolong the period of observation so that surgery or other adequate treatment is delayed.

The diagnosis of an acute obstruction is based on the distribution of the »natural» contrast, that is, the gas and fluid in the gut. When the findings are definite no other contrast is needed, but when doubt arises, or when repeated examinations are intended, we often have to use oral barium. An intestinal tube is rarely used in acute cases, at least for diagnostic purpose. If suction is administered the »natural» contrast is removed and the actual diagnosis as well as the prognostic conclusions

[1] Introductory paper given at the International Congress of Radiology in London 1950; submitted for publication, Sept. 21, 1950.

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are impeded or made impossible. We shall return to these questions subsequent to the presentation of the material.

Turning to the problem of the diagnosis, we should remember that there are essentially two varieties of mechanical obstruction, the simple occlusions and the real strangulations. Such a grouping is all important to the surgeons, concerning the diagnosis and treatment, and deserves also the most alert attention from a radiological point of view. In an earlier work, the author has compared various symptoms in these main groups of ileus and attention has been called to the scanty radiological findings in severe strangulating obstructions.

In simple occlusions only one portion of the gut is involved by intrinsic or extrinsic compression of the lumen, and the continuity alone is blocked. In real strangulations two barrels of the bowel are occluded and, in addition, the corresponding mesentery and its vessels are compromised. In the first instance nutritional disorder may develop at the site of blockage; in the latter group, the entire incarcerated loop may eventually become necrotic. Simple occlusions develop comparatively slowly, while strangulating obstructions show a more acute and severe course.

The simple occlusions are easily diagnosed except when the patient is admitted very soon after onset of the attack. They may be diagnosed as early as after 3—4 hours, but when at this time only a little gas and fluid have accumulated, the patient should be observed by repeated examinations. The findings are generally definite after 12—24 hours. The classical signs, with formation of fluid levels in more or less hoop-shaped loops above the stenosis, and little or no gas distal to the hindrance, are so well known that they no longer offer any particular problem.

On the other hand, the roentgen diagnosis of real strangulations still needs careful attention because they are often more difficult to diagnose, and a misinterpretation may be fatal. This is emphasized by the writer in many earlier publications. In order to further elucidate the question new observations are presented in the following.

Own Material

During the last 12 years 410 cases of internal small intestinal obstruction have been examined radiologically. During the same period a very large number of external incarcerated hernias and cases of other acute abdominal disorders were also examined, but they are excluded here. Only cases of true mechanical occlusions diagnosed *preoperatively* are listed, and all cases are proved to be so at operation, by the clinical course, or at autopsy.

Of these 410 cases, 59 were real strangulating obstructions with a shorter or longer loop of the gut impinged and more or less compromised. In addition, 17 cases were registered as volvulus of the small intestine, the torqued loop more or less afflicted, and 2 other cases also had a strangulated mesentery showing circulatory insufficiency. This makes 79 emergency cases, where the only adequate treatment is surgery as soon as the diagnosis is made. In the following only these cases will be the subject of a closer study. It is stressed that most of the cases of real strangulation were in women. In the material, 43 proved to be women and 6 men. The frequency of earlier operations in these cases is also emphasized. Among the women 30 had been previously operated upon, and 3 of the men had been submitted to surgical treatment. Evidently, it is hard to present ample evidences of such a relationship but it would not appear unlikely that adhesions secondary to earlier operation may play a decisive part in the development of the strangulating obstructions. Among the 17 cases of volvulus of the small intestine we found 8 men and 9 women, and 6 had been previously operated upon.

Diagnostic considerations

The main questions are: Do these cases show characteristic roentgen findings? Is it possible to make a definite diagnosis of the strangulating obstructions?

In order to answer these questions the cases are divided into two groups. 1. Those showing reliable and definite symptoms of an obstruction and 2. those showing poor findings (though proving of a real strangulation).

In the first group most cases presented either a partial or incomplete strangulation with slight compression or a short incarcerated loop. The findings are often quite similar to those of an ordinary simple occlusion, so that a radiological distinction may be impossible. This is rather important when we have to decide, based on the roentgen findings, if suction should be used or not. Our experiences indicate that a definite differentiation in many instances is extremely difficult even by the clinical examination.

Fig. 1 is the roentgenogram of a woman, admitted 24 hours after onset of symptoms. The diagnosis was small bowel obstruction probably situated in lower ileum and operation revealed a small incarcerated loop. Short bandlike adhesions were removed and a resection of 20 cm of gangrenous ileum was performed.

One exceptional case showed large loops of small intestine distended by gas and no typical tumor-like density though operation revealed

1 m of ileum not so severely damaged but resection had to be done and uneventful recovery followed. The explanation probably is that the patient was examined so late as 3 days after onset of the attack and that the incarcerated loop was only slightly compressed by the strangulating band.

These experiences prove again that incomplete strangulating obstruction or short loop incarcerations are rather difficult to distinguish from a simple obstruction. The same rule seems to be valid for the clinical examination as well. Certainly severe attacks and increased pain may arouse suspicion that a loop is strangulated but occasionally the clinical symptoms also may be scanty, the patient complaining of only moderate pains.

A closer study of the roentgen findings in this group of cases — the strangulating obstruction with unmistakable signs of ileus — indicates that rather long fluid levels with restricted movements are deserving of special attention. In one such case a large portion of the ileum was strangulated but no resection had to be made. Similar signs were found also in cases of volvulus of the small intestine (see later). Apparently the long levels are probably due to a reflex paresis, but to decide exactly whether the levels are located only in the prestenotic loops or also in the incarcerated loops, or in both places, is nearly impossible. These occurrences are not essentially diagnostic but are undoubtedly found more often in severe than in uncomplicated cases. Remembering the reverse situation, that definitely hoop-shaped loops with lively movements indicate a comparatively sound intestine, the sign is of certain diagnostic aid.

It should also be borne in mind that long fluid levels may occur as a result of an inflammatory lesion which in turn is complicated by a simple obstruction. Such lesions are, according to WANGENSTEEN, most difficult clinically to distinguish from real strangulating obstructions. The essential point is that in an obstruction due to an inflammatory process, a so called *combined ileus*, gas is practically always present in the colon and fluid levels are formed in that portion of the gut also, most distinguished in the cecum and ascending colon.

Is there any possibility of determining the site of the strangulation in these cases? Such an estimation is undoubtedly rather complicated but could possibly be made by examining the patient in various postures, to demonstrate a *fixation* of the incarcerated loops. However, in this group the imprisoned loops are distended mainly by fluid, and the prestenotic loops, more distended by gas, may move considerably, giving a false impression of the mechanism. More reliable is the usual observation that the stenosis is situated below the most caudal gas-filled loop, similar to what is found in ordinary simple obstructions.

Fig. 1. Short loop incarceration of small bowel under band-like adhesion, after oral barium. Findings similar to simple occlusion.

Fig. 2. Strangulating obstruction. 1 m of small bowel incarcerated under band. Note tumor-like density in lower part of abdomen. Displacement of barium-filled loops proximal to the stenosis.

As will be shown later the conditions may be quite different in complete loop obstructions, showing very poor roentgen findings.

The amount of free fluid in the peritoneal cavity is said to be more abundant in strangulating than in simple obstructions. Certainly, if much fluid is present this points toward severity of the obstruction but experience tells that the exact amount of fluid may be rather difficult to estimate just in these cases where the fluid-filled coils often dominate the lesser pelvis, simulating free fluid on the lower part of the abdomen.

Administration of oral barium

According to our opinion this question does not need any closer discussion. The innocuity of a proper barium suspension in cases of small intestinal obstruction is unquestioned (KOCH, FRIMANN-DAHL), and the great advantage of such a procedure is proven in hundreds and hundreds of instances. We have not tried umbrathor as advocated by CASE, but we find barium so easy (and cheap) to administer so there seems to be no need for a change. Principally, we try to advance the

diagnosis on the basis of plain films only, but we use oral barium very often in difficult cases, to verify the obstruction or to settle a differential diagnosis. When such a case is followed by repeated examinations the course of the ileus can be observed very precisely, and a development in one or the other direction, a deterioration or improvement, may be surveyed. Certainly, it is more easy to administer oral barium to patients with simple occlusions than with strangulating obstructions. It is mainly used in the first group but we cannot always decide beforehand which lesion is present and therefore barium also is given in the more severe cases. Occasionally, the administration of barium is of decisive value in strangulating obstructions.

In such cases a tendency to delay of propulsion, with retention, may be observed and the contrast is retained in the stomach and the upper jejunum, a sign which is more frequently observed in complete than in partial obstructions. However, if the barium suspension comes down toward the stenosis and is stopped by the hindrance the prestenotic coils may be *displaced by the tumor-like filling of the incarcerated loop*, which by virtue of its size will encroach upon the organs in close proximity, for example, proximal loops of small intestine, the stomach or the large bowel. (Fig. 2.) This patient was examined 36 hours after onset of the attack and the first examinations without contrast aroused suspicion of a small gut obstruction. However, 8 hours later, after oral barium, the diagnosis was made of real strangulating obstruction. This was confirmed readily at subsequent operation.

The other group of strangulating obstructions are those cases *showing few or poor signs of ileus*. Concerning the roentgen diagnosis, these cases are crucial, evidently because a delayed diagnosis may considerably increase the chance of a bad final result of treatment. The prestige of the roentgen examination may also suffer if a negative report is given and the operation reveals a large portion of small intestine to be gangrenous. In this material 22 such cases were separated and most of them proved to be completely incarcerated with strangulating ensnarements. In the following it is demonstrated that even if the findings are scanty they are at the same time characteristic and may give adequate holds for the diagnosis.

The salient features are that the incarcerated loops, containing fluid packed together, are giving a tumor-like filling most often found in the lower part of the abdomen and the minor pelvis. The density may show a polycyclic border which may indicate that the filling is outlined by the wall of the coiled strangulated loop. This is of aid to differentiate the density from *a torqued ovarian cyst*, a misinterpretation which may occur both radiologically and clinically. If one or several small fluid levels are located within the density this may give further evidence

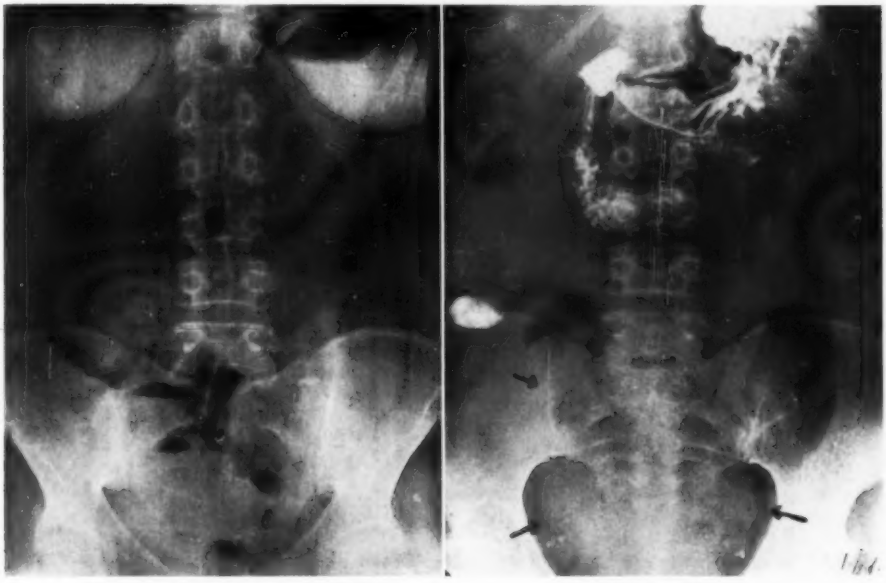

Fig. 3 a. Fig. 3 b.

Fig. 3. a and b. In erect posture (a) only some few levels are displayed. In supine position (b), tumor-like soft tissue mass in pelvis. 30 cm incarcerated, no resection. Recovery. Barium goes slowly down.

to the diagnosis of strangulation. In fig. 3 a case of real strangulation is presented 24 hours after the onset of the attack. A tumor-like density was found in the right iliac fossa and very little gas accumulated in the prestenotic coils, showing *remarkably few and short fluid levels*. They are approximately hoop-shaped, but without the tensed upright standing generally displayed in uncomplicated occlusions, and a large portion of the small intestine is displaced and seems to be pulled downward toward the incarceration.

Fig. 4 shows a strangulating obstruction 20 hours after onset of attack. In the lower part of the abdomen a soft tissue mass is seen and in left lateral position (b) the prestenotic hoop-shaped loop is observed. 30 cm of ileum was strangulated and discolored, but no resection had to be performed. Uneventful recovery.

As to the distribution of the gas, evidently this is not easy to decide. According to our experiences this important point, seen from a radiological point of view, is often neglected by the surgeons when the operative report is given. Certainly, the films may reveal the conditions

Fig. 4 a.

Fig. 4 b.

Fig. 4. a and b. Strangulating obstruction. Tumor-like density in lower part of abdomen (a). In lateral view (b), left side down, hoop-shaped loop proximal to stenosis. No resection. Recovery.

but to estimate exactly if the gas is present in the incarcerated loops or only proximal to the stenosis is often problematic. Here the *experimental investigations* are helpful and are referred to for details. Experience tells that only occasionally gas is present in the incarcerated loops, which in general are enlarged by increasing amounts of fluid. The possibility that some few gas bubbles (of swallowed air) may enter these loops cannot be ruled out. WANGENSTEEN has pointed out that transport is possible through a strangulated loop which at operation may give every evidence of lost viability. This may be the explanation why some gas at times is found in these loops. The production of gas within the strangulated loops (by putrefaction) may also be considered, but diffusion of gas from the blood into the intestinal lumen is certainly insignificant, if at all possible. Anyhow we may conclude that the old clinical rule of a local meteorism corresponding to the incarcerated loops, is not valid so far as the small intestine is concerned.

These cases also teach that the severity of an ileus cannot be estimated from the number and size of fluid levels as is maintained by some authors (RENDICH, ABRAMS and SAMUEL). On the contrary, the most severe cases of strangulation show sparing accumulation of gas and few short fluid levels. In simple occlusion most frequently the

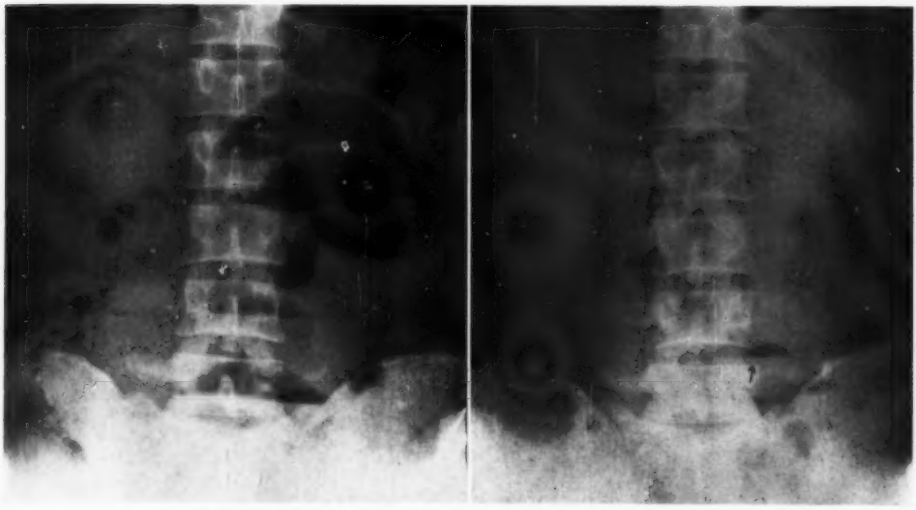

Fig. 5 a. Fig. 5 b.

Fig. 5 a and b. Same patient. a. Simple occlusion, due to band-like adhesion. Duration 17 hrs. . . . Operated. b. $^1/_2$ year later strangulating obstruction, 22 hrs. after onset, 20 cm resected. Note different appearance and scanty findings in the most severe condition. Operated, recovery.

number of fluid levels depends upon *the site* of stenosis and is greater the nearer the stenosis is situated to the ileocaecal valve. Next it is proportionate to *the duration* of symptoms and is generally increasing with the time from the onset of the attack. However, in a not insignificant number of cases — strangulating obstructions with a bad outlook for treatment — the increase in amount of gas and fluid levels is much less pronounced or may be missing.

But, also in these instances repeated examinations may give adequate information for the establishment of the diagnosis. The first films may exhibit very scanty findings and the next examination, for example 8 hours later, may give ample evidences of the condition. Such findings were made in a case of severe strangulation where 50 cm of the ileum was infarcted and found strongly discolored at subsequent operation. The first examination showed very little gas, whereas the next film showed small but definite hoop-shaped loops and short fluid levels. This proves that gas may accumulate and increase though very slowly, also in these instances.

Why do 1/3 of the strangulating obstructions show scanty gas-filling of prestenotic loops. Obviously, the passage is impeded and the intestine

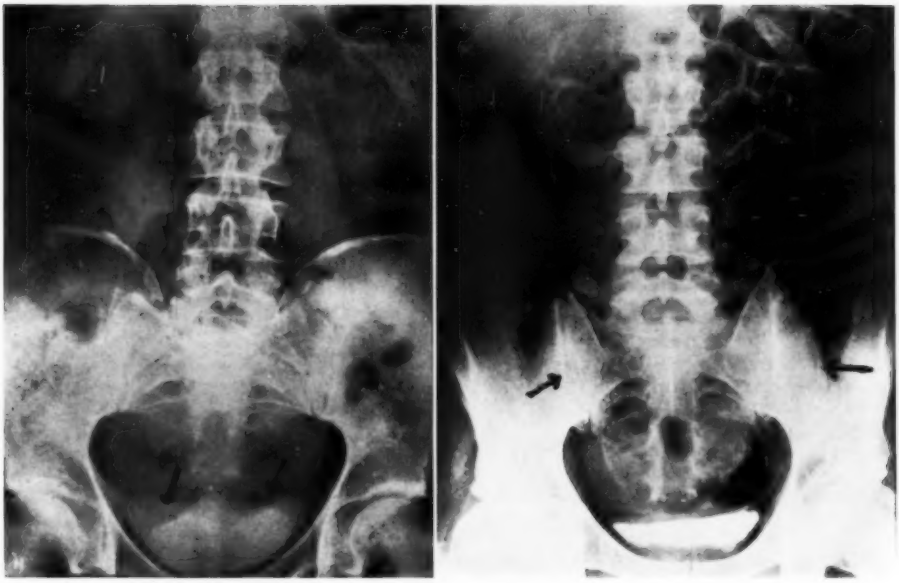

Fig. 6 a. Fig. 6 b.

Fig. 6 a and b. Strangulating obstruction after urography. a. Wave-like impressions upon the bladder, due to polycyclic border of incarcerated coil. b. Bladder compressed, ureters displaced by tumor-like soft tissue mass.

has lost its ability to propel the contrast toward the stenosis. The gut is paretic so that propulsion is inadequate and gas and fluid may even be repelled to the stomach, resulting in vomiting. The shock initiated by the strangulation may also play a part and the patient in a bad condition will do less eating and drinking, thereby swallowing little air. Certainly, here are many varieties but our experience points toward the fact that, the more severe the strangulation, the less gas is accumulated, making *the diagnosis most difficult in the most dangerous cases*. However, these cases occur infrequently and, though difficult, the diagnosis is not at all impossible, and the findings may even give holds for a specific diagnosis. We should think of a real strangulation especially if the patient is a woman of middle age, previously operated upon, complaining of severe pains in the abdomen, with some tenderness and rigidity, showing no sign of distension. Clinically, the patient may be suspected of having an ileus but also, for example, a perforated ulcer, a cholecystitis, a pancreatitis, an appendicitis, a ureteral stone or a torqued ovarian cyst. When, under these circumstances, some few coils

of small intestine are seen containing little gas and short fluid levels, and a tumor-like density is observed, the suspicion should arise of a strangulation.

Confirmatory signs are displacement of or impression upon the scanty gas-containing prestenotic loops. Upon these findings the radiologist will do well to worry sufficiently to bring about a searching reexamination, provided the patient has not come too late for the first investigation.

How is the gas distributed in the remainder of the bowel? Distal to the stenosis the small intestine is always found collapsed devoid of gas and fluid. In general, even the large bowel is empty and contracted, though occasionally very moderately distended, containing some fecal masses. Possibly the gas is due to putrefaction within the large bowel or some gas may have passed the stenosis and is then retained in the colon. Anyhow, our experiences show that gas in the large bowel does not rule out the presence of a strangulation of the small intestine and that a certain tendency for gas accumulation, more so in severe than in uncomplicated cases, must be considered. The secondary peritoneal irritation may here play a part. This is emphasized because it has been maintained that when gas is found in the colon an obstruction of the small intestine can be excluded. True, no gas in the large bowel is very often observed in small bowel occlusion and is confirmatory evidence of this lesion, but we must be careful of a reverse consideration that gas in the colon means no ileus of small intestine.

In the most severe cases the administration of oral barium is of restricted value, but may also be very helpful for the diagnosis. The barium may stop completely or be regurgitated to the stomach and not enter the involved loops at all. However, retention of the dye in the stomach and in the upper jejunal loops, for example after 6 hours, points undoubtedly towards a severe affliction of the intestine and may thereby indirectly contribute to a correct interpretation.

Are there other radiological signs pointing toward a strangulating obstruction? In five of our cases a *urography* was performed to rule out an acute ureteral stone which often is suspected by the clinical examination. A slight compression of ureters in the lesser pelvis was observed and a characteristic displacement of these structures toward the lateral wall. Also a compression of or a wave-like impression upon the bladder was seen, caused by the tumor-like coil of the incarcerated loops. (Fig. 6.) In male patients this sign seems as valuable as in female with other organs placed close to the bladder, estimation of such impressions is more problematic. In other instances the urography was quite negative.

How early can the diagnosis of a strangulating obstruction be made?

This question has been discussed in an earlier work and by many

other writers. According to OCHSNER the accumulation of gas in animals is greater in strangulating than in simple obstructions. This is not confirmed by our clinical and radiological experiences. In one of our cases (out of 60) the diagnosis was possible after 3 hours, but in most instances no definite signs were developed before 6—8 hours, and in some the diagnosis could not be made until 24 hours. In the more severe cases less gas was accumulated than in slight obstructions.

The use of the Miller-Abbott tube:

Certainly, there will always be different opinions as to the administration of the intestinal tube. It has a double task — firstly, to serve as a diagnostic means after injection of barium through the tube, and secondly, to serve as a therapeutic remedy by suction. No one denies the magnificant result obtained by using the tube in cases of incomplete intestinal stenosis when the local process is demonstrated after injection of small amounts of barium. Withdrawal of toxic fluid prior to the operation is certainly also a large step forward in the treatment of obstructions. In the post-operative period suction in the same way has a splendid effect.

Since our use of the tube in acute cases of obstruction is limited, the following line of argument is maintained:

Every 5th patient with small bowel obstruction of internal origin has a severe lesion and a compromised part of the gut may be expected at operation or autopsy. It is in many of these cases impossible to decide beforehand whether the intestine is damaged or not. If the bowel is strangulated it is generally accepted that the use of the tube is contraindicated. According to our experiences, the diagnosis of an obstruction is readily made in most cases, either on the plain films or after oral barium. Only few misinterpretations have occurred. In simple occlusions, without incarcerated loops, experience has taught that the lesion very often is due to strong adhesions and bands and that surgery is also here the adequate treatment in the great majority of instances. (KROOK.) By using oral barium the contrast descends in the course of 3—4 hours on the average, so even if the local process is not so precisely disclosed as after application of the barium through a tube, the diagnosis of the obstruction in itself is made better and more quickly and the patient can obtain early adequate treatment.

Differential diagnosis:

Difficulty in establishing the diagnosis is encountered occasionally in *simple occlusions* when these patients are admitted very early for

Fig. 7 a. Fig. 7 b.

Fig. 7 a and b. Volvulus of small intestine. a. Erect posture. Note long levels with restricted movements. b. An other case of volvulus after oral barium. Coil-like arrangement of twisted loops.

examination. Then the roentgen findings may be almost negative, but reexamination is in general decisive and if barium is given it will descend to the stenosis in the course of 4—6 hours, and the diagnosis can be readily made.

Volvulus of the small intestine. As such are only listed cases where a torsion or twisting was the primary cause of the lesion. The findings may vary greatly and are at times very similar to those of a strangulation, with very few and short levels and a tumor-like density in the lower part of the abdomen. However, in our material, consisting of 17 cases with volvulus, most of them showed signs of an ileus with abundant accumulation of gas and fluid and usually very long fluid levels were displayed. Three times the diagnosis was made of such a lesion based on the arrangement of the distended loops, which were observed lying as a coil, twisted or turned around, more or less radiating towards a center. This sign could be pointed out on the plain films taken in supine position and was also nicely portrayed after oral barium. (Fig. 7.)

Fig. 8. Mesenteric thrombosis. Paretic loops of small intestine. Stereotyped pattern of swollen mucous membrane.

In other cases of volvulus of small intestine the diagnosis was only that of a mechanical obstruction. As previously mentioned, long fluid levels showing restricted movements seem to indicate the presence of a mesenteric compression. In some cases this sign was also observed in volvulus combined with torsion of the mesentery, a condition which should be remembered as a possible diagnosis.

The findings in *torqued ovarian cysts* may provide a typical picture. The cyst appears as a density of variable size and is often fairly well outlined, better delineated and more dense than incarcerated loops of small intestine. As a result of the secondary peritoneal irritation due to the torqued cyst, some gas and fluid levels are found in the small intestinal loops and occasionally these are seen also in the lesser pelvis below the density corresponding to the cyst.

In *mesenteric* thrombosis gas and fluid may accumulate in the lower ileum resulting in formation of fluid levels and often a portion of the large bowel is also simultaneously involved. Occasionally, in these instances edema is present in the afflicted loops causing thickening and blurring of the mucosal folds. The decrease in auto-plastic movements

and peristalsis may likewise contribute decisively to the diagnosis. (Fig. 8.) In strangulating obstructions the incarcerated loops mainly contain fluid and the mucosal pattern is therefore invisible. The prestenotic loops may at times be hyperemic but only rarely edema develops here and consequently the chance to estimate this on the roentgen films is strictly limited.

In *perforated ulcers* the small intestine is rarely distended by gas or contains fluid levels. The pneumo-peritoneum is the salient feature in the establishment of the diagnosis. In obstructions due to internal strangulations a pneumo-peritoneum is extremely rare. We have observed free gas only in external incarcerations such as in umbilical and femoral hernias.

Exudative (*plastic*) *peritonitis* should also be taken into account. If fluid or fluid-filled coils are occupying the mid or lower portion of the abdomen and small intestinal loops are seen upward and to the left, the findings may simulate those of a strangulation. Gas-filling of the stomach and fluid levels somewhere in the large bowel are findings that may support a correct interpretation.

SUMMARY

Based on a material of 410 cases of small intestinal internal obstructions 60 cases of true strangulations were registered. These were divided into two groups, those giving clear evidence of an ileus and those giving poor roentgen findings. Added to these were 17 cases listed as volvulus. So in nearly every 5th case of small bowel obstruction a severely damaged intestine can be expected. The use of the Miller-Abbott tube in acute obstructions is very limited. The use of oral barium is advocated. This method is an aid to the diagnosis in many cases of simple occlusion, and is also used in incomplete strangulations and occasionally in severe incarcerations as well. The amount of gas or number of fluid levels may give evidence for estimating the duration and site of an obstruction, but does not give any reliable index to the severity of the ileus condition. On the contrary, in the most severe cases little gas is accumulated, and fluid levels are few and short. New and characteristic findings in these instances are pointed out.

ZUSAMMENFASSUNG

Das Material besteht aus 410 Fällen von Dünndarmverschlüssen. Von denen waren 60 Fälle echte Strangulationen. Diese wurden in zwei verschiedene Gruppen geteilt, die mit unzweifelhaften röntgenologischen Zeichen und die mit sehr wenigen Befunden einer Ileus. Dazu kommt 17 Fälle die als Volvulus des Dünndarmes registriert wurden. Damit zeigte jeder fünfte Fall von Verschlüssen eine ernste Schädigung des Darmes.

Bei akuten Verschlüssen wurde die Miller-Abbott Sonde nicht häufig gebraucht. Perorales Barium wird empfohlen. Diese Methode macht die Diagnose einfacher bei den glatten Verschlüssen, und ist auch ab und zu bei den inkompletten und schweren Strangulationen angewandt. Die Menge von Gas und Anzahl von Spiegeln geben Anhaltspunkte zur Beurteilung der Dauer des Darmverschlusses, gibt aber im Allgemein kein

Index für die Schwierigkeit des Ileus-Zustandes. Im Gegenteil, bei den schwersten Fällen ist wenig Gas ackumuliert, und Spiegeln sind kurz und wenige. Neue und karakteristische Befunde in diesen Fällen sind beschrieben.

RÉSUMÉ

Sur un matériel de 410 cas d'obstruction interne de l'intestin grêle on a enregistré 60 cas de strangulation vraie. Ces derniers ont été répartis en deux groupes, le premier où l'iléus était manifeste, le second où les signes radiologiques étaient peu nets. Il faut y ajouter 17 cas, étiquetés volvulus, où l'intestin grêle participait plus ou moins au processus.

Ainsi, dans presque un cas sur cinq d'obstruction du grêle il faut s'attendre à une lésion sévère de l'intestin. Le champ d'applications du tube de Miller-Abbot dans les obstructions aiguës est très limité. L'administration de baryum par la bouche est recommandée. Cette méthode aide au diagnostic dans beaucoup d'occlusions simples, et elle sert également dans des strangulations incomplètes, ainsi que, occasionnellement, dans des incarcérations graves. La quantité des gaz ou le nombre des niveaux hydro-aériques peuvent être des arguments dans l'estimation de la durée et du siège d'une obstruction, mais ne sauraient nullement indiquer de façon sûre son degré de gravité. Bien au contraire, c'est justement dans les cas les plus sévères qu'il y a peu d'accumulations de gaz, et que les niveaux hydro-aériques sont rares et courts. Des images nouvelles et caractéristiques trouvées à l'examen aux rayons roentgen sont rapportées.

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EXPERIMENTAL ILEUS IN RABBITS[1]

by

J. Frimann-Dahl

These investigations have been undertaken to demonstrate the distribution of gas and fluid in obstructions of the small intestine and to check the findings by repeated roentgen examinations. Many earlier works have been published on this subject, especially from the surgical point of view, but as the results and conclusions are still diverging, further experiments seemed justified. The acccumulation of gas and fluid in the involved loops gives the basic foundation for the diagnosis of ileus; they form, so to say, the natural contrast medium which, displayed on the films, gives evidence for the diagnostic conclusions. Therefore, a thorough understanding of the enteric conditions during the development of an ileus is imperative if the roentgen diagnosis of obstruction is to be advanced adequately.

So far as the simple occlusions are concerned, the diagnostic problems are less complicated than in strangulating obstructions. WANGENSTEEN and his associates have proved the significance of swallowed air in small gut obstructions in the genesis of distension. They concluded that about 70 per cent of the intestinal gas in obstruction originates from swallowed air and that 30 per cent is formed within the body. These results were not confirmed completely by the experiments performed by ANDERSEN and RINGSTED. These authors stated that in a so-called closed loop, or in a strangulated and stased loop, no gas at all developed. That means that no gas can be produced within the bowel by diffusion from the blood into the lumen. The condition is compared to a stased extremity in which formation of emphysema is as unlikely as gaseous distension of a stased intestinal loop. They also stated that there may be small, though insignificant, amounts of gas, originating from putrefaction.

From his experiments OCHSNER came to the conclusion that the ac-

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cumulation of gases in the bowel could be followed in animals by roentgen examination. He maintains that as early as 1 hour in strangulating obstructions, and 3 hours in simple obstructions, sufficient gas is accumulated to diagnose ileus roentgenologically. He is of the opinion that more gas is accumulated in strangulating than in simple obstructions, that is, the more dangerous the condition, the more gas is seen.

According to our clinical and experimental experiences this is not correct. On the contrary, in humans, in the most severe cases with complete strangulation of a large loop usually very little gas is accumulated and the roentgen findings are scanty. (FRIMANN-DAHL.) In animals the difference is not so remarkable, but as will be subsequently shown, most gas is present above the stenosis in simple occlusions and in strangulating obstructions little or no gas is seen within the strangulated loop. This means further that an attempt to grade the severity of obstruction proportionate to the amount of gas is a dangerous affair. We shall return to this later, subsequent to the presentation of the material.

Own Investigations

As mentioned above, the intention has been to investigate the development of various ileus conditions in rabbits and to demonstrate the accumulation and distribution of fluid and gas by means of repeated roentgen examinations.

40 rabbits were used for these experiments. The animals were narcotized and laparotomized and the small gut occluded or strangulated at selected places. The wound was closed and roentgenograms taken at various intervals until death. Then the intestinal tract was prepared and photographed in ordinary way, and colour pictures and roentgen films were made as well in most cases, both with vertical and horizontal direction of the rays. This was to better localize the gas and fluid, and to show the fluid levels in the specimens.

During the operations barium was injected into various portions of the gut — for example, above or below the stenosis, or within the strangulated loop, or at two places simultaneously. This method has the advantage that the condition of the intestine may be followed intra vitam and the incarcerated loop separated and localized on the films without any difficulty. When barium is not used as a means for a close localization it is impossible to distinguish the different loops during the course of the ileus. Certainly, one can determine from the gross specimen at autopsy in which portion of the gut the gas is accumulated, but the exact development of the obstruction after manifestation of the blockage and during life can only be adequately followed by repeated roentgen examinations.

The conditions used for the experiments were the classical procedure in 3 varieties: (1) a simple occlusion, (2) a double occlusion without interference of the blood supply (a closed but not isolated loop), and (3) a strangulated loop. Fig. 1 is a schematic drawing to show the various conditions in the investigations. In the first instance a simple occlusion was provided, with only one lumen of the intestine blocked and no interference with the mesentery and the blood supply. In the second group, two ligatures were placed, separated by a distance of 5 to 10 cm, and in most of these instances no ligatures were applied to the vessels.

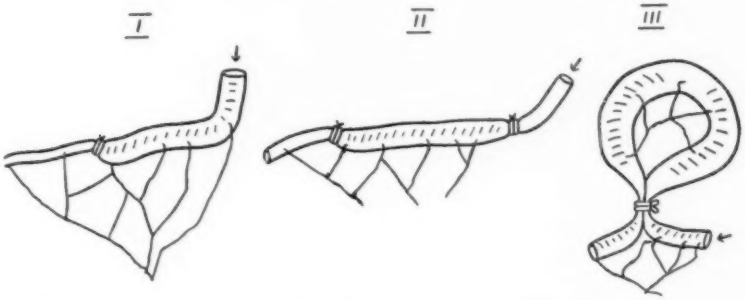

Fig. 1. Schematic drawing to show the application of the ligatures.

Only in some few of these instances was a ligation of the vessel performed, in order to see if any difference in the condition of the loop could be observed. In the last group a ligature was placed on a loop of the gut, the length of which varied from 5 to 15 cm. The knot was tied so firmly that the passage was completely blocked. A metallic suture was used in one series, but when a perforation at the site of the stenosis occurred, this method was abandoned and the usual catgut employed. A metallic suture has the advantage that it appears distinctly on the films and so the site of the stenosis may be pointed out directly. Especially in simple occlusions this method is useful. Strangulated loops are portrayed better and more separately after the injection of barium suspension. Exact gaseous analyses have not been performed in these experiments because the amount of gas accumulated was so small that no correct estimation could be expected.

1. Simple occlusions

In this group the lumen was tied off with one suture and a complete hindrance established. 7 animals were used, and as the findings were quite similar in all cases this procedure was discontinued. The findings

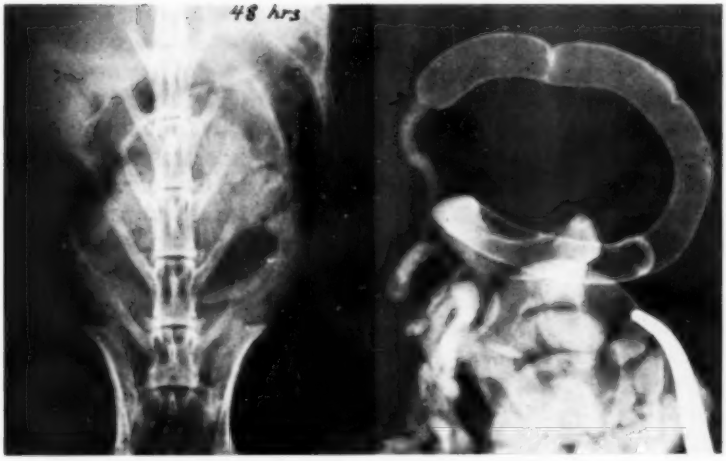

Fig. 2 a. Fig. 2 b.

Fig. 2. a. Simple occlusion, animal prone. Large distended loops proximal to stenosis.
b. Specimen shows distension of proximal loops, collaps of intestine distal to stenosis. No interference with mesenteric vessels.

were, in a way, stereotyped. Accumulation of gas was found in abundance proximal to the stenosis and hoop- or bow-shaped large loops developed, distended by gas, containing moderate amounts of fluid. (Fig. 2.) Distinct levels were displayed when horizontal directions of rays were used. In upright position the levels often were found at different heights in each limb of the loop, proving peristaltic activity. (Fig. 3.)

In lateral position with left or right side down the levels occasionally were rather long, measuring up to 5—6 cm. (Fig. 3 b.) Gas was observed very distinctly after 12 and 24 hours and usually increased until death. In one case a decrease in amount of gas was observed the last day. Evidently gas had been repelled to the stomach and the oesophagus.

In general the amount of gas was definitely larger in these cases than in the other groups and in one case a complete meteorism developed, the distended coils occupying the entire abdominal field. (Fig. 4.) At autopsy the prepared specimens showed findings which corresponded completely to the films made intra vitam. Here the site of stenosis is marked »spontaneously» by the metallic suture. The small intestine is distended by air all the way up to the stomach and completely collapsed distal to the stenosis, where the lumen is devoid of gas, contracted and narrowed. In none of the cases was any particular gas filling of the large bowel observed. This containing fecal masses pierced by small air bubbles

Fig. 3 a.

Fig. 3 b.

Fig. 3 a. Upright position. Hoop-shaped gas-filled loops showing fluid levels.
b. Right side down, similar findings. Stenosis at small metallic suture.

Fig. 4 a. Meteoristic distension in simple occlusion.

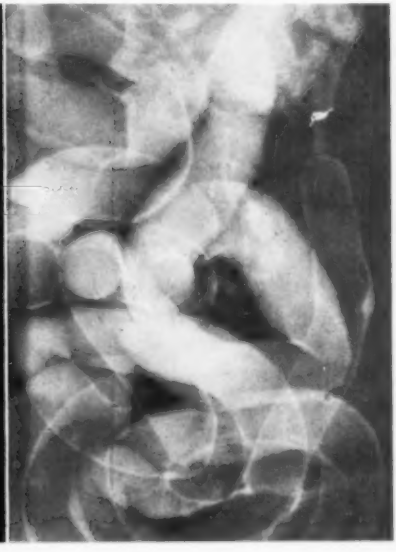

Fig. 4 b. Specimen shows site of stenosis.

was of normal caliber. Free fluid in the peritoneal cavity was rather scanty in all cases.

2. Double occlusion (a closed, not separated loop)

10 animals were used for these experiments. Various sorts of sutures were applied, including metal, silk and rubber, but the ordinary catgut proved to be most convenient. The ligatures were placed at a distance

Fig. 5 a. Specimen shows inspissated barium between ligatures (double occlusion).

Fig. 5 b. Roentgenogram shows retention of fluid and gas above stenosis, collapse below. Stc = Stomach. c = colon.

of about 10—15 cm and the findings in this group also proved a striking similarity. Salient features were: distension of the prestenotic coils, containing gas and fluid in abundance, thereby forming distinct fluid levels when horizontal direction of the rays was used.

Soon after application of ligatures the closed loop began to dilate, due to some accumulation of fluid. In several cases this process kept on until death and no gas at all could be demonstrated within the lumen. However, the findings were not always identical. When barium was injected in the isolated loop the proceedings could be followed closely.

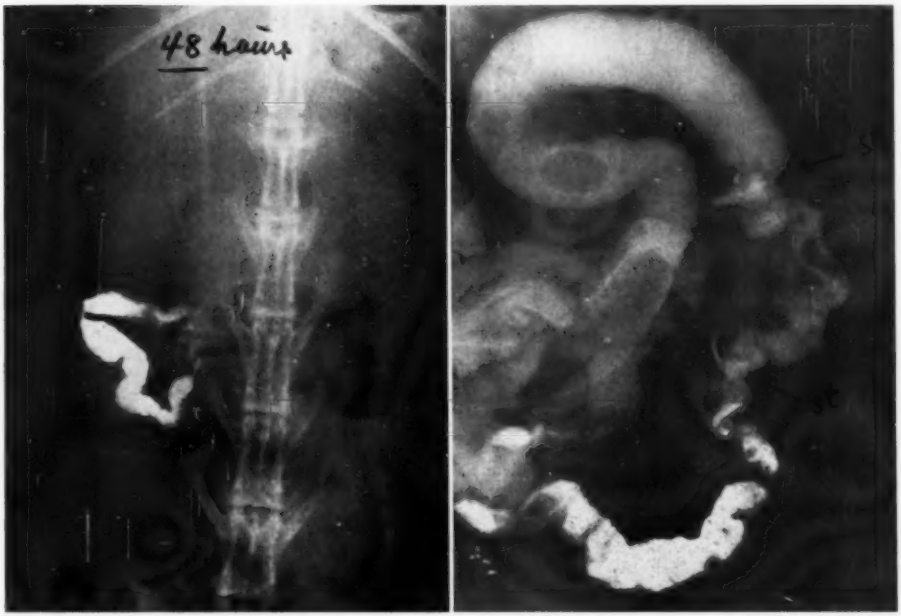

Fig. 6. a Double occlusion, animal erect. Retention of injected barium distal to stenosis.

Fig. 6 b. Specimen shows some few gas bubbles between ligatures. Injected barium above stenosis, diluted by intestinal fluid, gives only diffuse density.

In some instances the loop was dilated and filled with fluid during the course of the first days, but finally the barium suspension began *to inspissate* and the autopsy specimen revealed a contracted loop comprising clustered remnants of the opaque material. (Fig. 5.) The retention of the barium proves that the passage has been completely blocked by the ligatures and that a resorption of the extravasations and the fluid has taken place rather quickly. These findings were confirmed also in other cases. Distal to the stenosis the intestine in all events was collapsed and contracted, and some few small air bubbles could be demonstrated here on roentgenograms of the specimen. The insignificant amount of gas probably have come from post-mortem putrefaction. Observations of the propulsion of the lumen content are interesting. Barium was also injected *distal* to the stenosis and repeated examinations showed that it was completely retained. (Fig. 6.) Evidently, the intestine has lost its ability of transport and contraction in itself and the peristaltic movements cannot propel the content in the anal direction. When the stream

of secreted juices and food is stopped by a ligature, the transport of the fluid or semi-fluid content past the stenosis is also stopped and eventually the content is resorbed little by little. Evidently, in this part of the gut (distal to the stenosis) the resorption goes on while in the dilated part above the stenosis resorption is impeded caused by the stretching and compression of the small submucous vessels. When barium was injected in the prestenotic loops the contrast was soon diluted and in some instances was repelled back by antiperistaltic movements and was found in the stomach after 48 hours.

Fig. 7. High obstruction. Discolored strangulated loop. Above the stenosis fluid-filled upper jejunum, containing very little gas. Some few gas bubbles in collapsed distal part.

In one case in this group the large bowel was considerably distended by gas. No adequate explanation could be advanced for this finding, either intra vitam or at autopsy. Two ligatures were applied, so there is little reason to believe that some gas had passed the stenosis. Probably the gas was derived from putrefaction, and we should remember that the colon of a rabbit never is found completely devoid of gas, and contains large scybala masses. However, this exceptional finding with the colon distended by gas in a case of obstruction only confirms the usual rule of little or moderate amounts of gases in the large bowel in this lesion. Clinical and radiological experiences as well, show that occasionally some gas is found in the colon, though the stenosis is complete. This is often stressed by the writer and it is repeated here, that no gas in the colon is a valuable confirmatory sign of an occlusion, but such a lesion cannot be excluded if some gas should be found in that portion of the intestinal tract.

3. Strangulating obstructions

This group is composed of 20 animals. The ligatures were placed at various levels, in upper, middle and lower parts of the small gut. The loop was not stripped or in any way emptied of its content, but tied

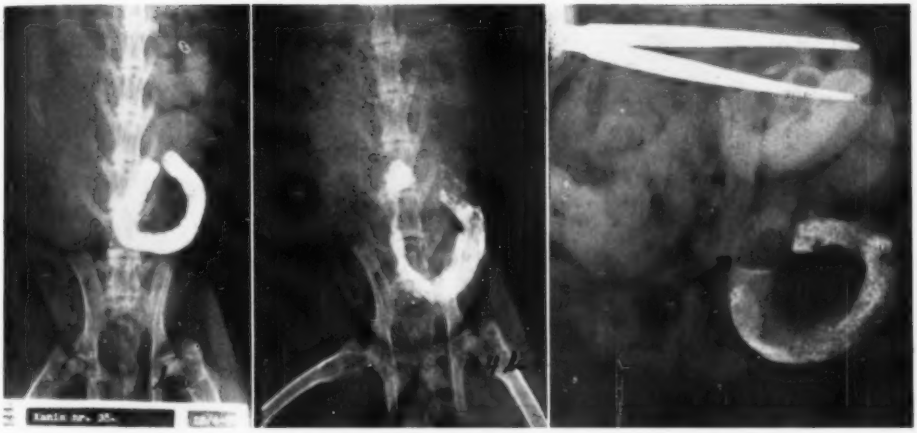

Fig. 8. Barium injected in strangulated loop. After 1, 24, and 48 hours. (Specimen.) Note increase in size and fragmentation of shadow due to sanguineous clotting. Small gas bubble has developed after 48 hours.

off in its natural or physiological condition. In all cases a striking similarity was observed, though some divergences were noted.

Proximal to the stenosis fluid was found in abundance and usually some bubbles of air were present so that fluid levels could be demonstrated readily both intra vitam and post mortem. In high obstructions gas was undoubtedly less pronounced than when the ligature was applied in the lower ileum. (Fig. 7.) The explanation of this seems to be that the gas is repelled back to the stomach much easier when the stenosis is high up in the gut. In none of the cases was the intestine found to be so distended by gas as in any of the cases of simple occlusions. And, evidently, resorption of fluid was decreased within the afflicted loops, more so in strangulating obstructions than in simple occlusions.

One might speculate why comparatively little gas comes down toward the stenosis in strangulating obstructions. We know that most of the gas is derived from swallowed air and probably the gut is more paretic in strangulations than in simple occlusions so that its ability to propel gas downward is diminished. Certainly, the animals are in a poorer condition after application of a strangulating than a simple occlusion, proven also by the shorter duration of life. Because of the shock and the reflex inhibition the animals take less food and do less drinking in strangulating than in simple obstructions. These statements seem to be in full accordance with the clinical and radiological experiences in these lesions.

Fig. 9. Barium-filled strangulated loop showing small gas bubble after 4 hours, increasing in size after 24 hours.

The strangulated loop

What is the condition of the strangulated loop? When a ligature is tied around two barrels of the intestine the mesenteric vessels simultaneously will be encircled and compressed. The intestinal lumen and the veins are most easily occluded while the passage through the arteries may persist, thus giving a stased loop which soon is dilated by fluid, followed by discoloration, edema and gangrene. In this way a sort of hemorrhagic infarction occurs, similar to the condition in mesenteric thrombosis with the exception that in the latter the bowel lumen is not occluded. In some cases evidently the blood supply was completely obstructed as no discoloration occurred at all, and only very little hemorrhage was found within the loop. This corresponded to what is called a pale or anemic infarction.

In general, the encircled loop, containing sero-sanguineous fluid, at autopsy was found to be at least doubled in size as compared to the size immediately after application of the ligature. (Fig. 8.) In 10 out of 23 strangulations a small gas bubble was shown on the films of the specimens. When in these instances the loop was severed under water a small gas bubble escaped and semi-fluid hemorrhagic content poured out. In the other cases no gas at all could be detected within the loop.

Distribution of the intestinal gas

The experiments proved that the best method of investigating the gaseous content was to make roentgenograms of the entire intestinal

Fig. 10 a. Fig. 10 b.

Fig. 10. Small gas bubble in barium-filled anemic loop.

tract after preparation of the autopsy specimen, in vertical position and with horizontal direction of the rays. Thereby, the findings intra vitam could be very closely compared with those at autopsy. In high obstructions very little gas was observed on the films made when the animals were alive. On the other hand, the portion of the small gut proximal to the stenosis always was distended by abundant fluid. The lower the stenosis, the more gas was present, but, as mentioned above, it never reached the amount which could be demonstrated in simple occlusions.

In approximately half of the instances a small gas bubble was present within the strangulated loop and this finding could also be demonstrated intra vitam.

Distal to the stenosis the small intestine contained some few very small gas bubbles and a similar finding was seen in the large bowel. In none of the animals in this group was there any distension due to gases in the distal portion, nor were accumulations of fluid demonstrated here.

From where is the gas derived? The main source of the gas in cases of obstruction undoubtedly is swallowed air. This is driven down toward the stenosis by the peristaltic movements of the gut and arrested here or repelled to the stomach by anti-peristalsis. Resorption of nitrogen

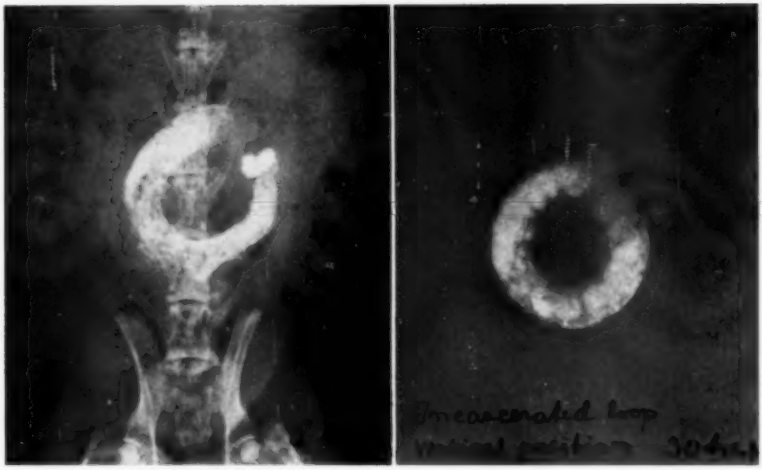

Fig. 11 a. Fig. 11 b.

Fig. 11. Characteristic motling and translucencies in barium shadow and strangulated loop due to hemorrhagic transudations. No gas present in specimen. Loop vertical.

is very slow, while other gases (CO_2 and O_2) are quickly resorbed and mostly expired with the respiratory air. Gases due to putrefaction are partly resorbed, partly discharged per anum. These experiments have proven that in some instances gas also is present within the strangulated loop. What is the origin of this gas? One could object that the gas may have entered the loop through the syringe when the barium was injected but this possibility may be excluded since no gas is displayed on the films taken immediately after the laparotomy. 4 hours later the first gas bubble is observed and is increased after 24 and 48 hours. (Fig. 9.) The air might have penetrated the stenosis at the site of the ligature, a possibility which is very difficult to exclude. However, gas was revealed in two instances of an anemic loop where the ligature evidently must have been so firmly tied that the arterial blood supply has been completely blocked. (Fig. 10.) Seemingly therefore the gas may derive from putrefaction or from the blood itself by diffusion. Which of these sources play the most important part could not be definitely decided by these experiments, but the findings point towards putrefaction as the main factor. We must content ourselves by stating that even though some gas may develop within the strangulated loop it is very moderate and does not play any significant part in the augmentation of the size of the loop. The increase is mainly brought about by transudation of sero-sanguineous fluid and clotting within the lumen.

On the films made of the preparations the hemorrhagic content of the loop is demonstrated and visualized by characteristic translucencies of the injected barium (Fig. 11). Here the barium is seen as a continuous band at the first examination, but the following exposures show a division or fragmentation of the contrast. The semi-fluid hemorrhagic transudation is not mixed with the barium suspension, causing defects of various size in the contrast band.

In 13 cases no gas could be detected within the strangulated loop. In these instances we have only to confirm other investigations, for example those made by ANDERSEN and RINGSTED, who concluded that no gas is derived from diffusion through the vessels into the lumen. However, these authors had only 3 animals in that group, which evidently are too few cases for a definite statement. They also stripped the intestine before ligation, whereas in our experiments the intestine was tied in physiological condition.

Duration of life:

On this point no exact conclusions can be drawn based on this material, but some observations should be noted. The duration of life was undoubtedly longer in simple occlusions than in strangulating obstructions. Some of the animals in the former groups lived up to 6 days while in the latter group death occurred usually after 24 to 48 hours. In high obstructions the animals died sooner than when the ligature was placed in the lower ileum. In strangulating obstructions in some instances the duration of life was only 18 hours. This confirms previous experiences relating to a more rapid course in high obstructions, and when the gut is incarcerated.

How early can the diagnosis be made?

As mentioned above OCHSNER has paid special attention to this question. According to our experiences small animals as rabbits are not particularly suitable for such observations. Further it should be remembered that the animals are laparotomized and consequently some air is present in the abdomen for a long time. 3—4 hours after the operation a pneumo-peritoneum can be observed and may be confused to intestinal gas. At this moment undoubtedly some fluid is accumulated above the stenosis so that suspicion may arise of an obstruction, but in most of the cases no definite fluid levels developed until 12 hours after application of the ligature. That more gas accumulates in strangulating than in simple obstructions could not by these investigations be stated, on the contrary, in simple obstructions much more gas was found than in real strangulations, and in the former group a distention and meteorism of the entire abdomen at times developed.

SUMMARY

In 40 rabbits experiments were undertaken to investigate the condition of the small intestine in simple and strangulating occlusions. The findings were controlled by repeated roentgen examinations intra vitam and compared with autopsy specimens. The greatest accumulation of gas was found in simple occlusions proximal to the stenosis. The distal portion was nearly devoid of gas and fluid. In strangulating obstructions moderate amounts of gas was found above the stenosis, where fluid also was present in abundance. Within the strangulated loop in about half of the instances a small gas bubble was detected, probably due to putrefaction or bacterial decomposition. The loop was always increased in size due to transudation of semifluid hemorrhagic content. The rule of a local meteorism in a strangulated loop seems not to be valid so far as the small bowel is concerned.

ZUSAMMENFASSUNG

Die Untersuchungen wurden an 40 Kaninchen gemacht, um die Befunde bei einfache Dünndarmsverschlüssen zu studieren. Die röntgenologischen Zeichen wurden den autoptischen im Vergleich gestellt. Die grösste Ansammlung von Gas wurde bei den glatten Verschlüssen im zuführenden Teil gefunden. Distal waren die Därme meist kollabiert und frei von Gas und Flüssigkeit.

Bei echten Strangulationen wurde Gas im zuführenden Teil gefunden wo eine starke Füllung von Flüssigkeit gezeigt wurde. In der strangulierten Schlinge war in der Hälfte der Fälle eine kleine Gasblase, vielleicht als Folge einer Verwesung und bakteriellen Dekomposition. Die Schlinge war immer vergrössert, von Flüssigkeit und koaguliertem Blut gefüllt. Das Gesetz einer »lokalen Meteorismus» der eingeklemmten Schlinge ist für die Dünndärme nicht gültig.

RÉSUMÉ

Des expériences ont été faites sur 40 lapins pour étudier l'état de l'intestin grêle dans les occlusions simples et dans les strangulations. Les constatations furent contrôlées par des examens radiologiques répétés intra vitam, puis comparées avec les pièces d'autopsie. La plus grande accumulation de gaz, dans les obstructions simples, fut trouvée en amont de la sténose. Le segment distal était presque vide de gaz et de liquide. Dans les iléus par strangulation on trouva des quantités modérées de gaz au-dessus de la sténose, où il y avait aussi du liquide en abondance. A l'intérieur de l'anse étranglée on découvrit dans environ la moitié des cas une petite bulle gazeuse, probablement due à la putréfaction ou à la décomposition bactérienne. L'anse était toujours augmentée de volume du fait de la transsudation de son contenu hémorragique et demi-fluide. La règle selon laquelle il y aurait un météorisme local dans l'anse étranglée ne semble pas valable en ce qui concerne l'intestin grêle.

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ANGIOGRAPHICAL DIAGNOSIS OF CAROTID BODY TUMOURS[1]

by

Hans Idbohrn

The carotid sinus, first described in homo by BURNS in 1811, is localized to the internal carotid artery where it appears as a slight bulbous dilatation at the bifurcation of the common carotid artery. In this region the wall of the artery is relatively less muscular but more elastic than elsewhere, and its adventitial layer receives a system of specialized sensory nerve endings. Impulses imparted to these receptors are transmitted to higher centres via the ramus caroticus of the glossopharyngeal nerve. The sinus may also receive twigs from the vagus nerve, the cervical part of the sympathetic and, possibly, also from the hypoglossal nerve.

These receptors respond to changes in the arterial blood pressure. Increase in arterial pressure in the region of the carotid sinus will cause a reflex fall in the blood pressure, slowing of the heart, decreased liberation of adrenaline from the suprarenals, slowing down of the respiration, accentuated peristalsis and possibly also other phenomena. Decrease of the blood pressure prevalent in the sinus will cause an increase in blood pressure, acceleration of the heart, increased liberation of adrenaline, hyperpnea, etc. The carotid sinus nerves and the depressor nerves of the aorta constitute HERING's four »Blutdruckszügler». They may possibly determine vagal tone, balanced by inhibitory impulses from sympathetic tone (ASK-UPMARK, 1935).

The carotid body, first described by VON HALLER (1743) as »ganglion minutum», is located at the bifurcation of the common carotid artery immediately behind the latter or medially behind the caudal part of the internal carotid artery. Topographically the carotid body is thus closely related to the carotid sinus, and most of the experimental studies

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on the function of the region of the bifurcation have been performed under conditions that do not always permit a clear distinction to be made between the function of the carotid sinus and that of the carotid body. According to general consensus, the carotid sinus is a receptor of hydrodynamic impulses, while the carotid body seems to react to humoral changes in the circulating blood (ASK-UPMARK 1935).

The Carotid Body, Anatomy, Physiology, Pathology and Clinic

The carotid body is 5—7 mm long, 2.5—4 mm wide, and 1—1.5 mm thick. It has a fibrous capsule and is attached to the wall of the carotid artery by means of a fibrous fatty stem, lig. Mayer. The carotid body is supplied with blood from the external carotid artery via vessels passing through this stem. Veins extend from the upper pole and empty into the superior laryngo-pharyngeal vein or into the lingual vein. Occasionally the carotid body seems to be divided by septa into loosely united parts, but usually no such division is discernible.

Histology: From the inner surface of the capsule extend fibrous septa that divide the organ into lobes, which are in turn divided into lobules by smaller trabeculae. This fibrous network contains myelinated and unmyelinated nerve fibres and ganglion cells and numerous nuclei. The cells in the lobuli are for the most part polyhedral and contain a rich amount of finely granular protoplasm. The cell walls are sometimes difficult to recognize. The nuclei are large, round or ovoid, they occupy an eccentric position in the cells and stain dark. Isolated sympathetic ganglion cells, plasma cells, and eosinophils are to be seen. The arrangement of the cells is not regular. The carotid body has a rich network of capillaries, which sometimes dilatate to form sinoids.

The endothelium of the arterial wall is thin. The capillaries are often looped or wound around about themselves and it was on account of this conglomeration that the organ was called »glomus caroticus.»

The histology of the carotid body changes with age, during childhood and adolescence it is small and the cells are predominant, in adulthood it achieves the size of a coffee bean and the capillaries and the stroma increase (BEVAN & MC CARTHY, 1929).

Physiology: The carotid body contains receptors that respond to chemical changes in the arterial blood, particularly those occurring in asphyxia, anoxia and acidosis. These changes elicit reflexes influencing respiration and circulation. Increased stimulation of the chemoreceptors causes increased activity of the respiratory and circulatory centres — hyperpnea and hypertonia, and vice versa (SCHMITH & COMROE, 1940).

Pathology: Manifest pathological changes are not common. Sclerosis may occur in the septa and in the vessels, and, in the event of infection, a cloudy swelling (ASK-UPMARK, 1935).

Carotid body tumours are, however, not rare. Up to 1945 no less than two hundred and seventy-five cases had been reported (GRATIOT, 1943; DICKINSON, 1945). They are generally slow-growing, round or ovoid, and the surface may be smooth or granular; they are solid and as a rule single, and may grow around and embed the internal, external, or common carotid artery. The proximal part of the external carotid artery is the part to be embedded first, and the internal carotid artery is not infrequently pushed backward by the tumour. The external carotid artery is sometimes elongated, especially in the region between the superior thyroid artery and the lingual artery, and surrounding structures are displaced to a varying degree.

Microscopically these tumours consist of typical glomus cells arranged in alveoli or in syncytial masses. A fibrous capsule is usually evident. In the presence of malignancy the alveolar structure is obliterated and the tumour cells grow diffusely and infiltrate the capsule (GRATIOT, 1943).

Clinic: The carotid body tumour is thus a solitary, slowly growing tumour, located at the bifurcation of the carotid artery.

PENDERGRASS gives the following diagnostic triad of the tumour (PENDERGRASS & KIRSCH, 1947):

1. Located at the bifurcation.
2. Palpable pulsations in the tumour.
3. Moveable laterally but not vertically.

Symptomatology: Although the tumour may be symptomless, it may press the surrounding structures and cause such symptoms as hoarseness, cough, dysphonia, dilatation or constriction of the pupils with or without narrowing of the palpebral fissure, nausea, vomiting, tachycardia, abdominal pain, obstipation, and tinnitus aurium. Local pain or pain in the arm and shoulder, and dyspnea or dysphagia have also been recorded (PENDERGRASS & KIRSCH, 1947).

Carotid sinus symptoms, drowsiness, giddiness, faintness and loss of consciousness are sometimes, though rarely, seen. In view of the intimate topographical relationship between the carotid sinus and carotid body tumours, the infrequency of such symptoms is remarkable. Probably these symptoms occur only in the presence of a hypersensitive carotid sinus, it being known that mechanical stimulation of hypersensitive carotid sinuses can produce the syndrome even in the absence of a tumour. The syndrome is elicited reflectorally along one of the three paths and gives different symptoms (GRATIOT, 1943).

1. Vagal stimulation with resultant asystolia, sino-auricular or auriculo-ventricular block, fall in the blood pressure and symptoms of cerebral anoxia.

2. Depressor effect with vasodilatation, fall in blood pressure and central anemia.

3. Cerebral type, when the impulses go direct t' 'e medulla and the hypothalamus.

Therapy: As these growths are radioresistant, surgery is the only treatment available (GRATIOT, 1943; PENDERGRASS & KIRSCH, 1947). The surgical removal presents technical difficulties on account of the intimate topographical relationship between the carotid artery, and the procedure is sometimes complicated by the necessity of ligating the common carotid artery or one of the main branches and then operative mortality is high, according to BEVAN (1929), about 30 per cent.

Prognosis: Carotid body tumours are usually (over 80 per cent) benign (BEVAN, 1929; PENDERGRASS & KIRSCH, 1947).

Local malignancy (different-sized cells, mitosis, infiltration of capsule), is sometimes seen, but remote metastases are rare (PENDERGRASS & KIRSCH, 1947).

Differential diagnosis: The tumour must be distinguished particularly from carotid aneurysm, lymphoma, aberrant thyroid tissue, branchogenic neck cysts and cancer (GRATIOT, 1943).

Angiography

The condition is rarely differentiated before operation (BEVAN & MC CARTHY, 1929); it would therefore seem desirable to try new diagnostic methods. These tumours are very vascular, so that it sounds reasonable to suppose that angiography might be useful in the establishment of a pre-operative diagnosis.

A perusal of the literature disclosed no case in which use was made of diagnostic angiography preoperatively. (LICHTENAUER reported 1938 a case in which carotid angiography was performed during operation.)

At the Roentgendiagnostic Department of the University Clinics, Lund, two cases of carotid body tumour have been examined by percutaneous angiography, and one, during operation.

Technique: The common carotid artery is punctured as far down the neck as possible by means of an ordinary carotid puncture needle. Ten cubic centimetres of 35 % Umbradil are injected quickly and two exposures are taken, one immediately after the injection and the other two seconds later. Lateral views are taken in a similar manner.

Fig. 1. Frontal view in a normal case. The common carotid artery extends essentially vertically. At the bifurcation the internal carotid artery swings first slightly laterally and then cranio-medially.

Fig. 2. Frontal view in case 1. The common carotid artery is wide and its course shows a marked outward bend. The bifurcation is widened and at the site of the tumour is a dense network of pathological vessels.

Case Reports

Case 1. Surg. Clin. 4284/1949. Woman, aged 53 years, sought aid at another hospital for ventricular trouble. At examination there a fluctuant formation, the size of a hen's egg, was observed in the right of the neck. She had had the swelling as long as she could remember, it had never given any pain but gradually increased in size.

A cyst of the neck was assumed and a biopsy specimen excised. The tumour was situated very close to the bifurcation of the carotid artery. Pulsations were palpated in the very vascular formation. The major part of the growth was encapsulated. Surgical removal was attempted but discontinued on account of repeated gushes of blood during the operation. The patient was then referred to the Surgical Clinic, Lund. On admission there her general condition was good. An egg-sized, fairly fluctuant growth was palpated in the right side of the neck. It was moveable laterally but not vertically. The carotid artery ran along the back of the tumour, through which pulsations were transmitted.

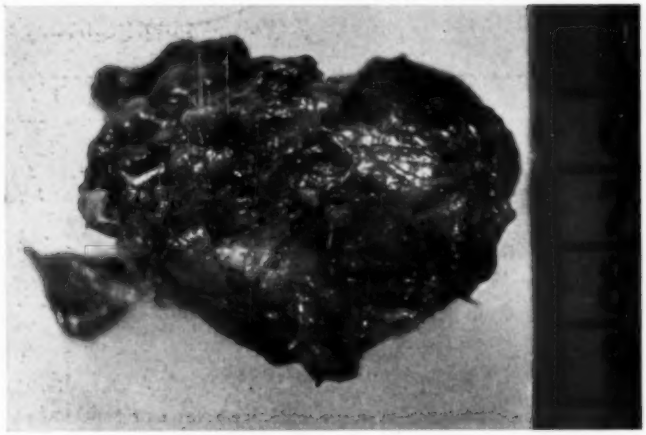

Fig. 3. The extirpated carotid body tumour was about the size of a hen's egg. It was solid, slightly lobulated and vascular.

Percutaneous carotid angiography of the right side was performed on 1. 11. 49 in the manner described above. A filling of the common carotid artery was obtained. The artery was found to be abnormally wide and to swing in a sharp bend to the right. At the bifurcation of the external carotid artery and the internal carotid artery was a dilatation, and here the carotid artery was displaced most. In an area (6 mm in diameter) corresponding in size and location to the manifest and palpable swelling of the neck a number of fine calibered irregular vessels were observed. Rather wide twigs branching from the internal carotid artery extended into the richly vascularized growth.

Rtg. diagnosis: Carotid body tumour (Fig. 2).

Operation on 6. 12. 1949 (STRÖMBECK). The tumour, which is very richly vascularized and surrounded by scar tissue after the earlier incision is situated immediately adjacent the main bifurcation of the carotid, where it has grown around the walls of the common carotid artery and especially the internal and external carotid arteries. Here a number of closely packed, fine-calibered arterial vessels enter the fibrotic wall of the carotid. The lower pole of the growth extends a few centimetres below the bifurcation, and the upper pole reaches the level of the junction of the anterior and posterior facial veins.

The tumour seems to originate from the bifurcation and the anterior aspect of the internal carotid and external carotid arteries, which are, however, not embedded by the growth, so that the latter could be removed without ligation of any of the main arteries.

Fig. 4. Frontal view in case 2. The common carotid artery is considerably dilated. Like the internal and external carotid arteries, it is pushed aside to a moderate degree. The fork is widened and a thin network of pathological vessels is seen in the tumour.

Pathology: Solid, egg-sized, vascular, fairly granular tumour (See Fig. 3). Microscopy — Carotid body tumour.

Case 2. E. N. T. Clin. 829/1949. Man, aged 40. For two and a half years he had noticed a symptomless, gradually increasing swelling on the left side of the neck.

Operation 14. 6. 49 (GISSELSSON). Exploratory incision over the bifurcation revealed a tumour that could not be separated from the vessels.

Percutaneous carotid angiography of the left side was performed on 28. 6. 49. A filling of the common carotid artery was obtained. The vessel was wider than usual. Like the internal and external carotid arteries, it had been pushed aside to a moderate degree. This displacement was greatest at the level of the bifurcation. The bifurcation was widened. At the level of the portion displaced most a thin net of delicate, irregularly disposed vessels was seen medial to the carotid artery.

Roentgen diagnosis: Carotid body tumour (Fig. 4).

Biopsy specimen showed the characteristics of a carotid body tumour.

In the following case angiography was not carried out until during operation.

Case 3. Surg. Clin. 300/1949. Woman, aged 31.

During pregnancy in 1945 the patient noticed a walnut-sized swelling in the left of the neck and sought aid at another hospital. Punctio produced blood. Radiotherapy was tried but found ineffective. The swelling increased, and by the time the patient came to Lund in 1949 it had assumed the size of a hen's egg.

Operation 20. 1. 49 (STRÖMBECK). The operatively exposed common carotid artery was punctured and contrast medium injected: the common carotid artery and the internal carotid artery were filled. At the site of the external carotid artery a marked accumulation of the contrast medium in the tumour was observed. The internal carotid artery showed a pathological forward bend. The examination was one of emergency and incomplete.

The operation specimen showed that the external carotid artery terminated in the tumour.

Pathologist's report: Carotid body tumour without signs of malignancy.

Comments

Carotid body tumours are anatomically intimately related to the carotid arteries, from which they are richly vascularized. The regular location and mode of growth of these tumours displace the carotid artery in a characteristic manner. On account of these features and their vascularity, carotid body tumours lend themselves to angiographical diagnosis. In the three cases reported a displacement of the common carotid artery and of the bifurcation of the internal and external carotid arteries was observed. The arteries were displaced laterally and the fold between them was widened. The displacement was greatest at the bifurcation. Several irregular vessels extended from the internal and external carotid arteries into the tumour where they give a vascular pattern of characteristic appearance.

These features permit a differential roentgen diagnosis of the tumour. Therefore it seems advisable to carry out carotid angiography in all instances of suspected carotid tumours.

SUMMARY

A description is given of the anatomy, physiology and pathology of the carotid sinus and the carotid body. The clinic of carotid body tumours is depicted, and it is claimed that carotid angiography provides a possibility of establishing a differential diagnosis pre-operatively.

ZUSAMMENFASSUNG

Beschreibung des Sinus caroticus und des Glomus caroticus, ihrer Anatomie, Physiologie und Pathologie. Die Klinik der Tumoren des Glomus caroticus wird vom Verfasser besprochen, der auf die Möglichkeit einer präoperativen Diagnose durch Angiographie der Carotis hinweist.

RÉSUMÉ

Description du sinus carotidien et du glomus carotidien, de leur anatomie, de leur physiologie et de leur pathologie. L'auteur expose la clinique des tumeurs du corpuscule carotidien et montre la possibilité de poser un diagnostic préopératoire grâce à l'angiographie de la carotide.

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THE USE OF TOMOGRAPHY IN DIAGNOSIS OF BASILAR IMPRESSION[1]

by

Vladimir Gvozdanović and *Sergije Dogan*

Basilar impression is a deformity of the skull characterized by dislocation of the basiocciput cranialwards. Consequently the upper part of the cervical spine is pushed up into the base of the skull. This or similar deformations have been named basilar invagination, convexobasia, and platybasia.

Basilar impression was first described by the pathologists: ACKERMAN (1790), ROKITANSKY (1846), BOOGARD (1865), and VIRCHOW (1876). BOOGARD had established criteria of his own for the measurement of relationships on the base of the skull. Even to this day Boogard's line and Boogard's angle are mentioned. BERG and RETZIUS (1855) were the originators of the term impressio baseos cranii, and VIRCHOW of the term platybasia. A progress in the study of basilar impression was achieved by the description of its roentgen picture (SCHÜLLER, 1911). However, this disease continued to be considered an interesting rarity only, where nothing could be done. After operative therapy had been suggested and even attempted by other authors, CHAMBERLAIN (1939) reported several cases treated surgically. Since then interest in this anomaly increased, and there appeared — especially in Anglo-American literature — detailed reviews of the diagnosis and therapy of basilar impression.

It is customary to differentiate between primary (congenital) and secondary (acquired) basilar impression. It seems that the majority of cases are due to congenital abnormality. As congenital anomalies often are multiple, basilar impression, too, is often accompanied by other

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anomalies of the skeleton, as for example assimilation of the atlas, malformations and dislocations of the odontoid process as well as numerous other anomalies of the cervical spine or of the base of the skull. Many of those anomalies may also appear independently, and some of them have been described first as isolated malformations.

Although these anomalies are congenital in the majority of cases, the neurological symptoms, if any, will appear later in life. The appearance of the patient may be characteristic if at the same time malformations of the cervical spine as KLIPPEL-FEIL's syndrome are present. Such patients will show a conspicuously short neck, with limited mobility and the growth of hair low down on the neck. The neurological symptomatology is relatively varied. It may suggest a process in the neighbourhood of the foramen magnum, but for exact diagnosis a detailed roentgen examination is necessary. Roentgen findings should be interpreted only in conjunction with the clinical picture, since anomalies of the nervous system (status dysraphicus, syringomyelia, Arnold-Chiari deformity etc.) may be present besides bone malformations. The clinical picture in basilar impression may resemble other neurological diseases as syringomyelia, disseminated sclerosis, amyotrophic lateral sclerosis, cerebellar or high cervical tumors etc.). This may be the reason that the disease can be overlooked, if we do not think of a possibility of bone abnormality.

Roentgen diagnosis. A definite diagnosis of basilar impression can only be made roentgenologically. SCHÜLLER, who was the first to describe the roentgen findings of basilar impression, reports the typical changes on lateral roentgen examination of the skull to be I) apparent constriction of nasopharynx dorsoventrally due to the high position of the cervical spine, II) cranio-convex configuration of the basiocciput, and III) high circular shadow of petrous bone. In the anterio-posterior roentgen examination SCHÜLLER reports I) increased distance between crista petrosa and the lowermost part of the occipital squama, II) projection of the atlas and axis into the upper part of the maxillary sinus, and III) cranio-convex line of the base of the skull, which projects into the sphenoidal sinus and extends inferiorly and laterally over the pyramids.

In the diagnosis of basilar impression by roentgen we employ either lateral pictures or sagittal tomograms, showing the odontoid process, foramen magnum, and hard palate. A line drawn from the posterior edge of the hard palate to the posterior edge of the foramen magnum represents the most reliable criterion for appreciating the degree of basilar impression. This line is called Chamberlain's line after the author who first recommended it for the determination of the position of the odontoid process. According to measurements performed by SAUNDERS in a hundred lateral roentgen examinations of normal skulls, the top of the odontoid process is situated in most cases 1 mm below Chamberlain's line,

while deviations of 3.6 mms are still within the limits of the normal. McGREGOR, who performed measurements in 205 pictures of skulls of Bantu negroes, arrived at almost the same results. It being rather difficult at times to establish the posterior edge of the foramen magnum in an ordinary lateral picture of the skull, McGregor recommends drawing a line from the posterior edge of the hard palate to the most caudal point of the occipital bone convexity; this is the so-called base line. In McGregor's opinion this line is more static than Chamberlain's because in basilar impression it does not shift upwards as may be the case with Chamberlain's line, whose position depends on the possible dislocation of the posterior edge of the foramen magnum. In 1947 JAMES BULL reported a new method for the determination of the degree of basilar impression. In a case of secondary basilar impression in a patient with Paget's disease he demonstrated clearly on a tomographic picture the angle between the plane of the atlas and that of the hard palate to be 42°. The normal relationship between these two planes should be roughly parallel, with the plane of the palate slightly above that of the atlas.

According to WELCHER the basal angle is enclosed by the lines nasion—centre of the fossa hypophyseos—anterior edge of the foramen magnum. It has no relationship to the position of the top of the odontoid process. Normally it amounts to about 135° with variations of $\pm$ 10. The majority of authors agree, that basilar impression is to be found relatively frequently without essential changes of the basal angle, so that the term platybasia should only be used in cases where the basal angle approaches 180°. McGREGOR thinks this angle to be of some clinical importance nevertheless, as it seems to him, that cases with an enlarged basal angle show a superior number of clinical symptoms.

In a lateral roentgen picture of the skull we can find a typical cranio-convex line of the base, furthermore signs of defects or hypoplasia of the posterior arch of the atlas, as well as possible changes in the configuration of the odontoid process and its position in the foramen magnum. In a lateral picture with maximum ventral flexion and maximum dorsal extension recommended by HADLEY, indirect signs of assimilation of the atlas can be established by the relationship between the posterior arch of the atlas and occipital bone. On this picture we can also establish a possible slipping of the atlas over the axis, which may give rise to compression of the medulla.

In the anterio-posterior picture we find changes on the atlanto-occipital joint, while the base of the skull has the appearance of a double sinusoid. In the axial picture we can establish changes in size and configuration of the foramen magnum as well as in configuration of the atlas, whereas the semi-axial picture according to LINDGREN shows impression of the occipital condyles.

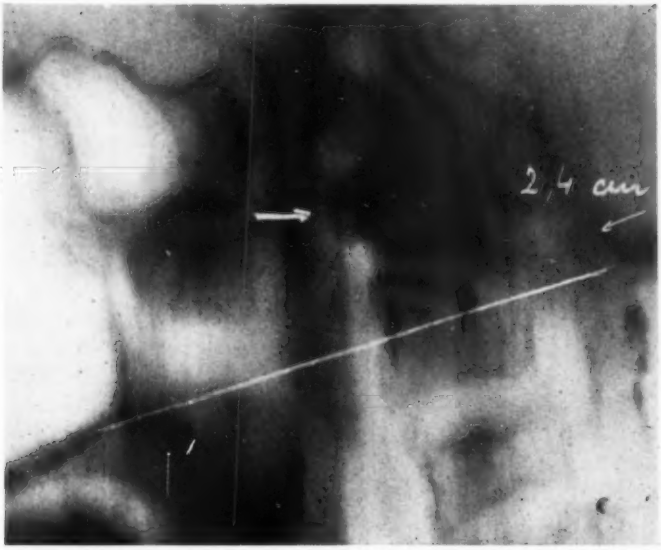

Fig. 1. Case 1. Basilar impression of high degree with dislocation of the top of the odontoid process 2.4 cms above Chamberlain's line.

The technical difficulties in the diagnosis of basilar impression are as follows: I) as a rule very poor visibility of the atlanto-occipital joints in the anterio-posterior picture owing to cranial dislocation of the base, II) difficulty of making axial pictures owing to shortness and poor mobility of the neck, and III) difficulty to establish the exact position of the posterior edge of the foramen magnum in the lateral picture.

By reason of what has been said above, we adopted in all our cases the tomographic technique, and that in lateral and frontal position. Tomograms taken in lateral position show very accurately the position of the top of the odontoid process in relation to Chamberlain's line, the defects, hypoplasia, or splittering of the posterior arch of the atlas, as well as the possible deformity of the odontoid process and its position in the foramen magnum (Fig. 1). Even when measuring according to BULL, a greater exactitude is obtained with tomographic than with ordinary technique. With tomograms taken in frontal position we are able to represent clearly the changes of the atlanto-occipital joints. (Fig. 3.)

As we can well see, roentgen diagnosis of basilar impression, thanks to the tomographic technique, has attained the exactitude of anatomo-

Fig. 2. Case 1. The pyramids are pushed cranially and lie at the level of the dorsum sellae.

pathological diagnosis. Therefore, the diagnosis of the basilar impression is purely radiological.

Recently we have the opportunity to observe three cases of basilar impression.

1) S. S., 20 years, car-mechanic, admitted 7th May, 1949.

History: A year ago pain began behind the left ear. In the last four months paresthesiae appeared in the left half of the head, neck, left shoulder and upper limb. Both arms became extremely weak, so that the patient was unable to close his fist completely.

At examination the patient was of short stature and mediocre development. Neck conspicuously short, its mobility slightly limited.

Flaccid weakness of both upper limbs, most pronounced in the distal parts. Moderate atrophy of small muscles of the hands and muscles of the right forearm. Dissociated hypesthesia of a syringomyelitic type over left half of the head and neck, left upper limb, and upper part of the thorax up to a height corresponding to the fourth dorsal segment. Deep reflexes in the right arm and leg very active, in the left arm they were absent and in the left leg normal. Abdominal reflexes weakened on the right side, normal on the left.

Roentgen finding: Basilar impression of high degree with shifting of the top of the odontoid process 2.4 cms above Chamberlain's line. (Fig. 1.) Tops of the pyramids pushed up cranially and lie at the level of the dorsum sellae. (Fig. 2.) Basal angle 140°. BULL angle 143°. The posterior arch of the atlas assimilated with the occipital bone. Tomogram in frontal plane shows ankylosis in both atlanto-occipital joints. (Fig. 3.) Foramen magnum normal. Fusion of the bodies of C 5—C 6 and C 7—D 1 vertebrae. Deformations of intervertebral foramina in the cervical spine. Spina bifida C 7 and D 1.

Fig. 3. Case 1. Tomogram in frontal plane shows ankylosis in both atlanto-occipital joints.

Between vertebras D 2 and D 4 hemivertebra right. Pronounced dextro-convex scoliosis of upper part of thoracic spine. Anomalies of the ribs.

Owing to steady progression of the clinical symptoms, on the 27th June 1949 decompressive craniotomy of the posterior cranial fossa and laminectomy of two upper vertebrae were performed. (Neuro-surgical department, Zagreb, operation performed by Dr M. Kožic.) Dura was left open. After operation considerable improvement of

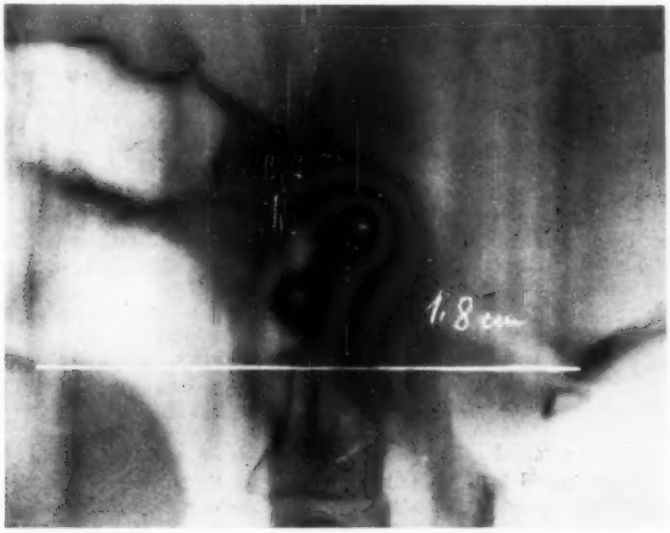

Fig. 4. Case 2. Basilar impression. The odontoid process lies obliquely backwards, its contours being slightly irregular and its top dislocated 1.8 cm above Chamberlain's line.

Fig. 5. Case 3. Sagittal tomogram in mid line shows the top of the odontoid process 1.2 cm above Chamberlain's line.

paresis in the arms could be observed. The other symptoms remained unchanged. The patient was again able to return to work.

2) V. Ž., 25 years, student, admitted 31st October 1949.

History: Since 1945 gradual weakening of right arm and leg.

Examination: Patient was of asthenic built. No outer signs of anomalies in question.

At neurological examination a right spastic hemiparesis was the most conspicuous feature. Movements of hand and fingers incomplete, those of foot and toes almost impossible. Rather marked atrophy of muscles of right arm and leg. Movements of all extremities showed moderate ataxy. In right extremities hypesthesia for all qualities of sensation. Cranial nerves were normal, except that right sternocleidomastoid muscle was paretic. Deep reflexes in both arms absent. Of abdominal reflexes only the lower left was present. Patellar and Achilles reflexes markedly intensified, right more than left. Plantar reflex absent on the left, extensory on the right.

Roentgen finding: Basilar impression with dislocation of top of the odontoid process 1.8 cms above Chamberlain's line. Odontoid process lies obliquely backwards, its contours somewhat irregular. (Fig. 4.) Basal angle 140°. BULL angle 142°. Atlas shows hypoplasia of posterior arch, which is open dorsally. Foramen magnum without special features. Assimilation in the right atlanto-occipital joint. Intensified lordosis of cervical spine. Bones of hard palate not united in medial line. Lumbar pneumo-encephalography showed normal endocranial subarachnoid and ventricular spaces.

Operation performed 12th December 1949 (Dr. N. POPOV) in the same manner as in first patient. Marked arachnoid adhesions found in the region of the cisterna magna. Right cerebellar tonsil prolonged downwards like an uvula, while left one normally situated. This finding would speak in favour of a slight Arnold-Chiari deformity.

After six months condition essentially unaltered. Only insignificant subjective improvement of movements in right extremities.

3) R. J., 25 years, field laborer.

Admitted to the clinic for traumatic contusion of brain. Conspicuous appearance on account of short neck and pronounced kyphoscoliosis, which, according to history, developed in second year of life.

No anomalies of neurological status.

Roentgen finding: Sagittal tomogram shows in mid line top of the odontoid process 1.2 cm above Chamberlain's line. Basal angle 140°. BULL angle 148°. (Fig. 5.) Foramen magnum and atlanto-occipital joints without pathological changes. Thoracic vertebral column shows marked dextro-convex scoliosis and kyphosis with deformity of the ribs and bodies of vertebrae.

While we think the first two cases to be congenital anomalies, we believe the third to be a case of secondary ricketic basilar impression.

SUMMARY

A short historical survey of basilar impression is given. The roentgenological diagnosis is described and the importance of tomographic technique of basiocciput in lateral and frontal planes emphasized. Three own cases of basilar impression are reviewed.

ZUSAMMENFASSUNG

Es wird ein kurzer historischer Überblick über die Basilar-Impression gegeben. Die röntgenologische Diagnose wird beschrieben und die Wichtigkeit der tomographischen Untersuchung der Hinterhauptsbasis in lateralen und frontalen Ebenen betont. Drei eigene Fälle von Basilar-Impression werden besprochen.

RÉSUMÉ

Les auteurs passent brièvement en revue l'historique de la gouttière basilaire. Ils en exposent le diagnostic radiologique, et soulignent l'importance des tomographies de la partie basale de l'occiput dans les plans latéral et frontal. Ils rapportent trois cas personnels de gouttière basilaire.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR: DR. L. GLÜCKER) OF THE »CARMEL»-HOSPITAL OF THE JEWISH WORKERS SICK FUND IN HAIFA, ISRAEL, AND THE ROENTGEN DIAGNOSTIC DEPARTMENT (DIRECTOR: PROF. ÅKE ÅKERLUND) OF KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

INTRAMURAL DIVERTICULOSIS OF THE GALLBLADDER[1]

Case Report

by

L. Glücker

Although diverticulosis in the wall of the gallbladder was known to surgeons and anatomo-pathologists since the 17th century (and in accordance with the investigations of ROBERTSON and FERGUSON it was found in about 50 % of all, clinically diseased, gallbladders explored) it was not till 1948, that the first reports on the roentgenological visualization of the diverticula during cholecystography appeared.

The diverticula were first described by MALPIGHI and RUYSCH as »miliary gland formations in the wall of the gallbladder», then rightly recognized by ROKITANSKY as »hernia-like outpouchings of the gallbladder mucosa», but later again called by LUSCHKA: »plentifully branched glands». In ASCHOFF's description these »herniated, sometimes richly branched outpouchings of the wall of the gallbladder» are called »Luschka's ducts» or »Luschka's diverticula».

MARCH in his publication on »Visualization of the Rokitansky-Aschoff Sinuses of the Gallbladder during Cholecystography» gives the description of the first roentgenologically and anatomo-pathologically examined case. He emphasizes, that a search of the literature revealed no record of roentgenologically recognized diverticula in the wall of the gallbladder.

Some months later appeared ACKERMANN's report on the second case of »Diverticulosis of the Gallbladder» visualized by means of cholecystography.

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In September 1948 ÅKERLUND & RUDHE examined the third case and published it in February 1950 as: »Intramural small-cystic diverticulosis of the gallbladder», and in December 1948 I had the opportunity to investigate during cholecystography the fourth — below described — case of intramural diverticulosis of the gallbladder.

It is somewhat striking that till 1948 no roentgenological report on intramural diverticulosis appeared, although — as all authors emphasize and as my own case also shows — the roentgen picture is so characteristic, that the diagnosis can undoubtedly be made without anatomopathological confirmation. Then at once four cases are recognized during cholecystography in one year, in countries far away one from another. As — for years — there was no essential improvement of the method of cholecystography, which would permit better conditions for the visualization of intramural diverticulosis, it can probably be assumed, that the roentgenological changes, although existing, were not correctly interpreted. The precise examination of 14 published cases of »acute pneumocholecystitis» undertaken by ÅKERLUND & RUDHE seems to confirm that assumption. The quite similar radiological appearance of some of the reported cases (as *e. g.* described by CULVER & KLINE) showing a »gas filled gallbladder with gas penetrating the mucosa and lying in the planes of the gallbladder wall» is identical with the cholecystographic picture of intramural diverticulosis, but was not recognized as such by the authors. Although there are certain conditions required for the demonstration of the diverticula during cholecystography (such as good contrastfilling of the gallbladder, sufficient number and size of the diverticula, which must be empty and wide-necked enough to allow the entry of the contrast medium) it is hoped, that intramural diverticula will be demonstrated and recognized more frequently.

Case history:

The patient K. E. a 57 years old, corpulent woman, had 7 years ago infection with dysenteria. Since about two years frequently pains in the right epigastrium in form of attacks without fever. No icterus. On palpation tenderness and sometimes swelling in the liver region.

Cholecystography (Pheniodol peroral) performed on 7. 12. 1948, shows (fig. 1) good concentration of the contrast medium in a gallbladder of normal size and position. The border of the gallbladder, especially at the fundus, seems to be less sharp — as the exact examination of the original film shows — there are many small dots of contrast medium, separated from the contrast filled lumen of the gallbladder by an indistinct, narrow, non opaque line.

After a fat meal (fig. 2) the gallbladder contracted to about a half of the former size. Now the dots of contrast are seen throughout the shadow of the gallbladder. They are distinctly larger, and seem in some places to merge with the contrast filled lumen of the gallbladder, probably as an expression of the contrast filled short necks of the diverticula.

Fig. 1. The border (especially at the fundus) of the — otherwise quite normal — gallbladder appears less sharp. This is caused by many very small, contrast filled diverticula, separated from the lumen of the gallbladder by a narrow, non opaque line.

Fig. 2. After a fat meal: The gallbladder is contracted to about a half of the former size. The diverticula, much enlarged, are now seen around all the shadow of the gallbladder. They seem to confluate on some places with the lumen of the gallbladder through the contrast filled short necks of the diverticula.

The radiological demonstration of the intramural diverticula of the gallbladder deserves our interest also for another reason: Already ROKITANSKY could establish small concretions in a number of the examined diverticula. In ASCHOFF's opinion the diverticula formed through prolonged stasis and intracystic pressure in the dyskinetic gallbladder from the normally existing, small cysts in the wall of the gallbladder, play an important rôle in the pathogenesis of the cholelithiasis.

ÅKERLUND on the basis of his »cholecystographic study of the layer formation and sedimentation phenomena of the gallbladder» pointed out the possibility that the origin of the aseptic cholesterol stones could be ascribed to the crystallization of cholesterol from the highly concentrated residual bile, sedimented in the gallbladder. The deep and narrow intramural diverticula offer the best conditions for retention of such bile, and thus for the formation of concretions.

Repeated cholecystographic demonstration of intramural diverticulosis of the gallbladder, in which with improved technic perhaps concretions could be seen and their development by serial examinations observed, may contribute to the definite knowledge of the mechanism of cholelithiasis.

SUMMARY

A case of intramural diverticulosis of the gallbladder is described and a short survey on the former publications is given.

ZUSAMMENFASSUNG

Nach kurzer Besprechung der früheren Publikationen wird ein Fall der cholecystographisch dargestellten intramuralen Diverticulosis beschrieben.

RÉSUMÉ

Après une courte revue des publications précédentes l'auteur rapporte un nouveau cas de la diverticulose intramurale de la vésicule biliaire.

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SOME EXAMPLES OF THE DIAGNOSTIC VALUE OF PERCUTANEOUS CAROTID ANGIOGRAPHY[1]

by

Knut Koppang

Since EGAZ MONIZ some decades ago introduced cerebral angiography as a new diagnostic procedure, considerable progress has been made in various fields of neurodiagnosis. This applies particularly to procedures for diagnosing cerebral tumors where carotid angiography supported by electroencephalography has supplemented and to some extent replaced pneumographic examination. Cerebral angiography has proved particularly valuable for determining the exact type of cerebral lesion. Moreover, the risk involved by the use of this method is negligible.

The use of cerebral angiography in neurologic practice has been greatly facilitated by the development of the percutaneous technique, the success of which has caused the method to be now accepted as a routine examination. The examination does not actually require hospitalization of the patient. The following figures illustrate this: At Rikshospitalet, Oslo, cerebral angiography was performed in 114 cases in 1945, while it in 1946 was performed in 350 cases, and in 1949 in 614 cases. The increased use of the method during the latter years is primarily due to the adoption of the percutaneous technique instead of operative exposure. Moreover, in 70 of the 614 cases in which carotid angiography was performed the examination was carried on an ambulatory basis (these 70 cases also include patients from other hospitals). Surgical exposure of the carotid artery during the years mentioned has only been used when separate filling of the external carotid vessels has been desired. It seems that on the whole unsuccessful results can be almost completely eliminated by the use of the percutaneous technique. In this respect the value of a permanent highly trained staff (nurses) is emphasized. Further, the examiner should be acquainted with the patient's clinical condition so

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that he will be able to decide whether the examination is actually indicated, and so that he will know what to look for and what precautions to take to control possible complications. As an example of the effectiveness of the percutaneous method it can be mentioned that adequate filling of the intracranial vessels for diagnostic purposes was obtained in 354 of the 359 angiographies as performed by a single examiner during 1949.

The technical performance of the percutaneous method is based on experience as published by various authors during recent years, and reference is made to publications by EMBLEM, LINDGREN, KRISTIANSEN, ENGESET and KRISTIANSEN, and ENGESET and KVADSHEIM. A detailed description of the technique now in use at Rikshospitalet will be found in a recent work by TORKILDSEN. Our technique varies considerably from that described by WICKBOM (1948). We have found it preferable to puncture the common carotid artery, while WICKBOM's technique employs puncture of the internal carotid, *i. e.*, puncture at the point where pulsation is felt most cranially on the neck.

Experience has shown that various examiners do not master the technique to an equal degree, and a successful performance consequently depends to some extent on individual skill. The main requirement, however, is personal experience, and no one can be expected to master the method until after having performed a couple of hundred percutaneous angiographies.

The object of this paper is to present some examples of the diagnostic value of the percutaneous cerebral angiography, and to show how the examination may form a basis for effective treatment.

The first of the following examples is a case of thrombosis of the internal carotid artery.

Case 1. The patient, a 46-year-old man, was admitted to the Department of Neurology of Rikshospitalet, Oslo in October 1948. In July of the same year he had received a heavy blow on the head from an iron bar. Symptoms of dysphasia developed a few days later, and paresis of the right arm and leg one week after this. Mental changes in the form of impairment of memory and concentration power also developed. Neurologic examination showed slight spastic paresis on the right side, dysphasia, and mental slowness as the main symptoms. The blood pressure was 135/90. BWR was negative. A roentgenogram of the skull was normal. Electroencephalography showed »some degree of cerebral dysrhythmia, most marked over the left hemisphere».

Percutaneous carotid angiography was performed on the left side (Fig. 1). As seen from the angiogram only filling of the external carotid and its branches was obtained. This aroused a suspicion that occlusion of the internal carotid might be present, for which reason carotid angiography was performed on the right side some days later (Fig. 2). The latter examination gave a normal vascular picture on the right side but also gave complete filling of the left carotid and its branches. This feature we considered as indirect evidence of occlusion of the left internal carotid indicating that a collateral circulation had been established via the circle of Willis with the left hemisphere receiving its blood supply from the right internal carotid artery. Final proof of this was obtained

Fig. 1.

Fig. 2.

Fig. 1. Case 1. Angiography on the left side. Note filling of the branches of the external carotid only.

Fig. 2. Same case. Angiography on the right side. Note filling of the branches of both internal carotids.

some time later when a second carotid angiography performed on the left side revealed thrombosis of the left internal carotid just above the bifurcation (Figs. 3 and 4).

Moniz has described a syndrome occurring in this condition of which the main characteristics are: Intermittent headache, transient paresis (which may become manifest successively) opposite to the side of the lesion, aphasia when the dominant hemisphere is affected, and mental changes. The presence of these symptoms, particularly in young subjects, should always arouse suspicion of thrombosis of the internal carotid. Endarteritis obliterans, syphilis, and trauma are the etiologic factors most frequently involved.

The case shows that when carotid angiography gives filling of the external carotid only, the examination should be extended so as to include visualization of the remaining arteries of the neck in the same seance. This implies that the roentgenograms must be developed immediately and that the examiner be acquainted with the patient's clinical condition.

Case 2. Figures 5, 6 and 7 are angiograms from a 60-year-old man who was admitted as an emergency case to the ENT Department of Rikshospitalet in April 1949 and who was suspected to be suffering from cerebral complications caused by a left-sided

Fig. 3.

Fig. 4.

Fig. 3. Case 1. Angiography on the left side. A. P. view. The exposure is made just after the injection had started. Thus the arteries of the neck are visible on the radiogram. Note that the contrast medium stops in the internal carotid just above the point of the needle which is situated within the carotid bifurcation. Also note the presence of contrast medium below the tip of the needle, indicating the entering of contrast medium into the lower portion of the artery against the blood stream.

Fig. 4. Same case. Lateral projection.

otitis media. On admission the patient was delirious, but his relatives supplied us with the following informations:

During the past few years the patient had suffered from continuous discharge from the left ear with impaired hearing on the same side. During the fourteen days prior to admission severe headache, partly in the form of attacks associated with vomiting, had developed. For the last few days prior to admission he had been somnolent, partially unconscious and delirious, and slightly febrile. Two days prior to admission the discharge from the left ear increased producing an abundant fetid pus.

The temperature was 37.8° C; blood pressure 170/110; sedimentation rate 24 mm; white blood count 14,700. The spinal fluid was normal, and there was no neck rigidity. Neurologic examination showed motility and reflex changes of the right extremities indicating a lesion in the left hemisphere. The clinical signs were not very marked, but were unequivocal. On the basis of these findings resection of the left middle ear was performed but pus was not present except in the external and middle ear. Three small exposure openings made at different places showed no signs of dural involvement. As no improvement had occurred by the next day, electroencephalography was performed. Pathologic tracings were obtained, but definite evidence of a localized lesion was not revealed. Percutaneous cerebral angiography was therefore performed on the left side. To our great surprise the first injection of contrast medium in the frontal projection

Fig. 5.

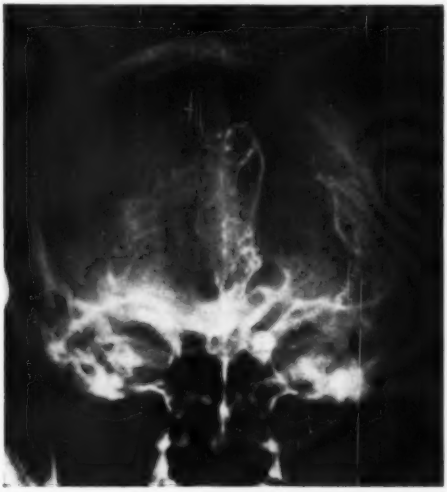

Fig. 6.

Fig. 5. Case 2. Angiography on the left side. The angiogram shows a comparatively large expansive process on the right side.

Fig. 6. Same case. Angiography on the left side with compression of the right carotid during the injection of contrast medium. Note increased distance between the middle cerebral artery and the cranial wall on the right side as compared with the left.

showed an expansive lesion on the right side with considerable dislocation of the anterior cerebral artery to the left (Fig. 5). It was immediately attempted in the same seance to produce filling of the branches of the right carotid by compressing the artery on the neck during the injection of contrast medium, but, as shown in figure 6, conclusive angiograms were not obtained. However, the films were highly indicative of an extracerebral expansive lesion on the right side, since the distance from the cranial wall to the middle cerebral artery was considerably larger on the right side than on the left. The needle was removed, and percutaneous carotid angiography was performed on the right side also ten minutes later despite the serious condition of the patient (coma, arterial hypertension, increased blood urea (75 mg/100 ml) which generally are considered a contraindication for intravasal injection of contrast medium). However, the establishment of an exact diagnosis was considered essential in this case. Moreover, the patient had not become worse as a result of the first examination. The second angiography was easily performed and the film (Fig. 7) showed clearly the exact type as well as the site of the lesion, viz., an extracerebral hematoma on the right side. Figure 7 shows the phlebogram as exposed 3.5 seconds after the arteriogram. The latter did not — as so often happens in these conditions — reveal the type of the lesion as clearly as did the phlebogram. A lateral projection produced additional evidence as to the exact site of the lesion. The patient was operated on the same day. Two holes were drilled in the skull, one corresponding to the coronary suture and one posteriorly in the right parietal region. From the posterior drill-hole in particular,

Fig. 7.

Fig. 8.

Fig. 7. Case 2. Angiography on the right side; phlebogram. Note the distinct avascular zone.

Fig. 8. Case 3. Ventriculogram showing two narrow layers of gas laterally on both sides.

a spurt of thin dark-brown fluid shot out following opening of the dura. Except for thin membranes which were removed piece by piece through the widened drill-holes, there was nothing to indicate the presence of a larger organized hematoma. The patient improved during the operation. He was soon able to speak and made a rapid recovery. One week later he was ambulatory and feeling well, and cure has so far persisted (Sept. 1949).

This case illustrates very clearly how difficult the establishment of a correct diagnosis may be in the case of an intracranial lesion in a comatous patient. In the present case the condition was masked by an otitis media which actually had nothing to do with the condition threatening the patient's life. However, vague, but definite clinical signs indicating a lesion in the left hemisphere were present. Identical findings were made by several examiners. One week after the operation signs of a lesion in the left hemisphere were still present in the form of inversion of the right plantar reflex. This might very well have been due to other causes — cf. the patient's age and the arterial hypertension with possibility of a previous vascular lesion. In particular, however, the case illustrates how an apparently brisk diagnostic procedure, viz., bilateral carotid angiography on the same day in an elderly, comatous patient with arterial

Fig. 9.

Fig. 10.

Fig. 9. Case 3. Angiography on the right side with compression of the left carotid during the injection of contrast medium. Note considerably avascular area over both hemispheres.

Fig. 10. Same case. Lateral view. Angiography on the right side. Note severe depression of the frontoparietal vessels.

hypertension and increased blood urea, may form an adequate basis for effective therapy.

Several publications have been issued, showing the great value of cerebral angiography in diagnosing intracranial hematomas (ENGESET, WICKBOM, KRISTIANSEN).

Percutaneous cerebral angiography may also reveal the presence of an extracerebral collection of fluid in infants. Case 3 illustrates this.

Case 3. 5-year-old girl. The parents had noticed that from the age of about 2 years the child was whimpering and obviously mentally underdeveloped. The head seemed remarkably large, which was confirmed by neurologic examination, the circumference of the head measuring 58.5 cm as against 50 cm as normal for the age. Otherwise the examination revealed nothing abnormal. Ventriculography was performed on June 15, 1949. The intraventricular pressure as measured in connection with the examination showed no particular increase indicating the presence of a hydrocephalus internus. However, assurance was not had that the needle was within the ventricular system. The ventriculograms showed irregular large air-filled cavities with fluid levels, and one of the frontal films (Fig. 8) showed two symmetrically arranged layers of gas laterally. As the gas was suspected of being situated extracerebrally, percutaneous cerebral angiography was performed on the right side with the patient under general anesthesia. By compressing the left carotid during the injection of contrast medium, bilateral filling was obtained

(Fig. 9), and the angiogram showed bitemporal collection of fluid extracerebrally. The lateral view (Fig. 10) showed marked dislocation of the frontoparietal vessels. With this as a tentative diagnosis, operation was performed on June 20, 1949. An osteoplastic flap was formed on the right side. Following opening of the dura, a capsule appeared which was opened. Entrance was thus gained to a large cavity filled with fluid. The brain was adherent to the skull anteriorly by a sagittal membrane through which a similar fluid-filled cavity could be seen over the left hemisphere. After emptying the cavity, as much as possible of the capsule surrounding the hygroma was removed. The result of the microscopic examination of pieces of the removed capsule was recorded as »wall of subdural capsule».

The patient made an uneventful recovery and was ambulatory after about one week. Any particular change of the mental condition was not noted. Follow-up examination has not showed demonstrable improvement of the mental changes, though the parents stated that the child seemed a little more alert than prior to the operation.

In this case it seems very unlikely that the operation might have contributed to much improvement of the patient's condition, particularly as far as mental changes are concerned, in view of the fact that the brain appeared to be too abnormal and that the changes had persisted too long a time. The subdural collection of fluid had no doubt started soon after birth. Attention should be paid to the possibility of a similar condition in infants in the presence of indicative symptoms. Subdural puncture through the anterior fontanel will give conclusive diagnostic evidence and may effectively cure the condition (INGRAHAM, WALTHER).

At any rate, it must be regarded as an important advance that such a condition can be visualized in a 5-year-old child by percutaneous carotid angiography as in the present case. The method is applicable even in smaller children. In two children of the age of 3 years, percutaneous carotid angiography was performed with the patient under general anesthesia. One was a child with epileptic seizures of a focal type, and the other a child with acquired hemiparesis where clinical examination suggested the presence of a supratentorial expansive lesion. The angiograms showed nothing abnormal in any of these cases. In both instances use was made of 6—7 ml of contrast medium instead of the usual 10 ml per injection. In the first case dilatation of the pupil and loss of the pupillary reflex occurred on the homolateral side following the injection. These symptoms, however, disappeared within ten minutes.

SUMMARY

The present paper deals with the extended use of the percutaneous method of carotid angiography, the percutaneous technique having replaced operative exposure almost completely. Three cases are reported to illustrate the great diagnostic value of this method of examination. The procedure is applicable even in young children. In one case of a 3 years old child where the method was used dilatation of the pupil and loss of the pupillary reflex occurred on the homolateral side following the injection. These symptoms, however, disappeared within ten minutes.

ZUSAMMENFASSUNG

Die vorliegende Arbeit befasst sich mit der vermehrten Anwendung der percutanen Methode bei der Angiographie der Carotis. Die percutane Technik hat fast vollständig die operative Freilegung ersetzt. Zur Darstellung des grossen diagnostischen Wertes dieser Untersuchungsmethode werden 3 Fälle gebracht. Das Verfahren ist auch bei kleinen Kindern anwendbar. In einem Falle, wo die Methode bei einem 3-jährigen Kind vorgenommen wurde, trat Pupillen-Erweiterung und Ausbleiben des Pupillen-Reflexes auf der homolateralen Seite im Anschluss an die Injektion ein. Die Erscheinungen verschwanden jedoch nach 10 Minuten.

RÉSUMÉ

Le présent travail traite de l'emploi extensif de la méthode transcutanée dans l'artériographie carotidienne, cette technique transcutanée ayant presque complètement remplacé la mise à nu du vaisseau. Relation de trois cas pour illustrer la grande valeur diagnostique de cette méthode d'examen. Le procédé est utilisable même chez de jeunes enfants. Dans le cas d'un enfant de trois ans où l'on s'en était servi, on vit apparaître, à la suite de l'injection, une mydriase avec perte du réflexe pupillaire, du côté homolatéral. Ces symptômes, cependant, disparurent en moins de dix minutes.

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A CASE OF URETEROCELE[1]

by

J. R. von Ronnen

It is true that the roentgen signs of ureterocele have been appreciated for a considerable time, and have indeed often been described (ÅKERLUND, HELLSTRÖM, R. WILLIAMS, VORSCHÜTZ, RUDHE). The writer realizes that he can make no important contribution to the subject but nevertheless feels that a modification of the usual technique has resulted in such a remarkable series of roentgenograms, that a short publication seems justified.

A soldier, aged 32 years, was admitted to the Army Hospital in May 1949, complaining of difficulty in passing his water, and some degree of obstruction. He had no pain, and no previous symptoms apart from a vague history of passing urine of a reddish tinge some ten years previously. No abnormal signs were apparent on examination: a trace of albumen and a few leucocytes and epithelial cells were noted in the urine. In the preliminary roentgenograms, the renal areas were normal but a small oval calcified opacity was noted apparently lying to the right of the coccyx. After the introduction of the contrast medium into the blood system, it was seen that the left pelvis and ureter were normal but that there was some clubbing of the minor calices on the right side. There was considerable dilatation of the lower part of the right ureter and in the bladder in the region of the right ureteric orifice a translucent ring, about 3 cm in diameter and ranging in thickness from 1 mm to 3 mm, was apparent. The opacity previously noted was situated in the middle of this ring. The signs were considered to be typical of a ureterocele with a probable calculus (»drumstick» or cobra-head appearance of the distal and intravesical part of the ureter). (Fig. 1.) The bladder was emptied by means of a catheter and re-filled with oxygen,

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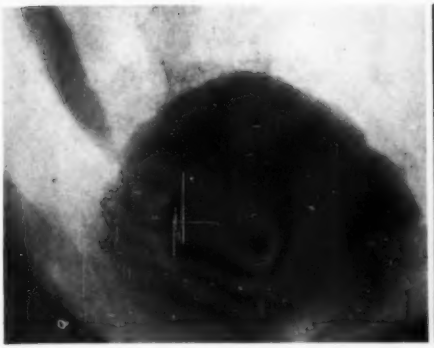
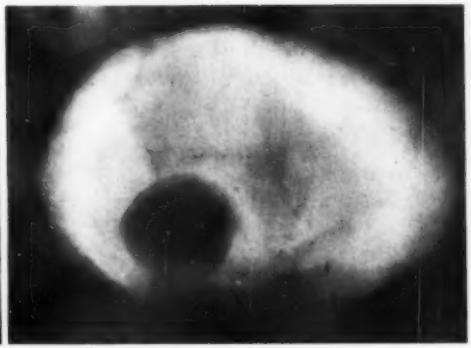


Fig. 1.



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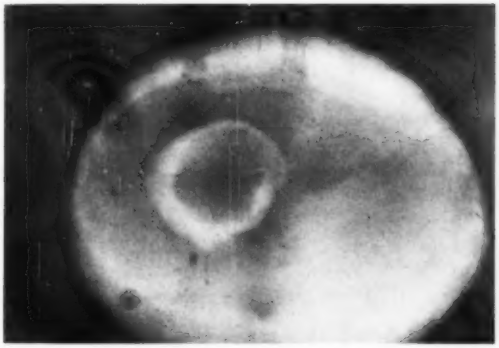

Fig. 3.

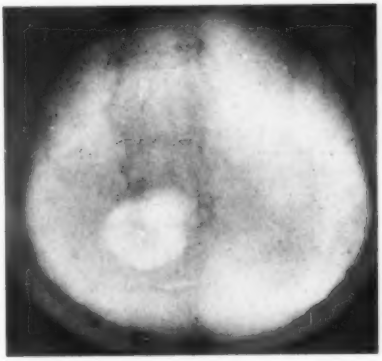

Fig. 4.

after which lateral films were obtained. The ureterocele was now visible outlined by the oxygen, as a more or less rounded shadow lying in the inner side of the posterior wall of the bladder. In the anterior-posterior films the ureterocele was seen to retain the contrast medium and its wall appeared as a ring-like shadow between its contents and the oxygen. (Fig. 2.)

At fifteen minutes, the ureterocele was seen to be filled with urine of about the contrast density as that in the bladder, and consequently the wall of the ureterocele now appeared as a translucent ring. (Fig. 3.) The appearances are very similar to those noted at the commencement of the examination. At thirty minutes, the ureterocele containing the stone was still visible, although the characteristic ring had disappeared

because the density of the wall and the density of the urine in the ureterocele are now the same. (Fig. 4.)

The roentgen diagnosis was later confirmed by cystoscopy and at operation.

SUMMARY

Description of the various roentgen features of a case of ureterocele.

ZUSAMMENFASSUNG

Beschreibung der verschiedenen Röntgenbilder bei einem Fall von Ureterozele.

RÉSUMÉ

Description des différentes images radiologiques d'un cas d'urétérocèle.

REFERENCES

A detailed list of references is given in the article by U. RUDHE: »A typical roentgen picture of very large ureteroceles», Acta radiol. 29 (1948), 396.

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HISTOLOGICAL AND CYTOLOGICAL CHANGES PRODUCED BY ALPHA-PARTICLES IN THE SKIN OF MICE[1]

by

Finn Devik

In the vast amount of literature describing the effects of ionizing radiations in living organisms, relatively few papers deal with the effects of external alpha-rays.

The range is so short, that, for instance, the alpha-particles from the decay products of radium hardly penetrate the superficial, horny, dead layer of the epidermis in man.

Accordingly, investigations of the actions of external alpha-rays have mostly been concerned with very small objects, *e. g.* bacteria, and fern spores (ZIRKLE, 1935, 1940).

Therapeutically the alpha-rays are used to a rather limited extent. Some use is made of thorium X, in the form of a solution, which is painted on the skin (LOMHOLT, 1923, 1936), and as an ointment containing radon (LANGE, 1945). Applied in these ways, it is not possible to calculate the skin doses in roentgens or equivalent units; nor is the effect totally ascribable to alpha-rays only.

LARKIN (1941) describes the clinical findings in human skin after an accidental bombardment with alpha-particles from a cyclotrone.

The effects of alpha-rays from radio-isotopes within an organism have been more extensively dealt with in the recent literature. But in experiments with internal alpha-emitters it is difficult to calculate the doses given to the different tissues.

The epidermis of mice is thin enough to permit the alpha-particles from »natural» radio-isotopes to penetrate into living tissue.

The purpose of the present experiments has been to investigate the

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effects of alpha-rays upon the mouse skin following irradiation from an external source of known intensity, stating the doses in physical units.

It may be of interest to note, that as the alpha-rays hardly penetrate even to the most superficial capillary loops, the experimental conditions may be regarded as an intermediate between irradiation *in vivo*, and irradiation *in vitro*.

Materials and Methods

In the experiments 8—12 weeks old mice from a strain of recessive hairless mice have been used. These mice have a skin which is practically hairless. Accordingly, depilation and the following irritation is avoided, and the pure radiation effects on the skin are easily observed. The thickness of the epidermis, in sections, may vary from less than 10 μ, and up to 20 μ or more. The whole skin is 2—500 μ thick.

Polonium was chosen as a convenient source for emission of alpha-particles. The energy of the alpha-particles is 5.3 MeV. The range is 3.84—3.87 cm in air, and it is supposed to be about 39 μ in tissue.

The polonium preparation, which was procured from the »Radioactive Products Corporation», New York, consisted of a small nickel sheet, 1 cm² square and 0.1 mm thick, covered with 10 millicuries polonium on the one side.

In order to calculate the doses received by the skin at various distances from the surface, the ionization produced in air was measured in an ionization chamber using a mirror galvanometer, in conjunction with screens of aluminium foil, varying in thickness between 6.7 and 19.8 μ. With the unfiltered preparation the ionization was too intense to obtain a saturation current, even when applying a potential difference of 2,500 volts to the electrodes. But the use of any of the aluminium foils permitted a saturation current to be attained at about 1,600 volts or less, indicating that the measurements might be relied upon as a base for calculating the doses from the amount of ionization.

The following readings were registered:

Aluminium foil, thickness in μ	Voltage, volts	Distance between electrodes	Ampères $\times 10^{-7}$
0	2,500	3.9 cm	5.1
6.7	»	2.7 »	2.05
6.7	»	2.4 »	2.07
9.9	»	» »	0.97
13.6	»	» »	0.31
16.6	»	» »	0.05
19.8	»	» »	(0.007)
55 (control)	»	» »	0.00

The range of the alpha-particles from polonium in aluminium is 22 μ (JOLIOT-CURIE, 1946).

LEA (1946) has calculated the range in tissue of density 1 g/cm³ to be 38.9 μ. Direct measurements of the range of alpha-particles in liquid water have given lower ranges, from 32 μ upwards (MICHL, 1914; as calculated from PHILIPP, 1923; APPLEYARD, 1949). As no direct measurement has been made of the range of alpha-particles in tissue (as far as known to the author), and as the atomic elements constituting wet tissue differ considerably from those of water, the value 38.9 μ as computed by LEA will be used in the following calculations.

The polonium-covered nickel sheet was mounted in a small celluloid holder, 1—1.5 mm behind an opening of the same form and size as the sheet, cut in the celluloid. A fine wire across the opening helped to prevent the aluminium foils and the mouse skin to touch the polonium. Accordingly the alpha-particles had to travel 1—1.5 mm in air before entering the aluminium foil or the mouse skin. It will therefore be assumed, that the effective ranges of the alpha-particles in aluminium and in the skin were 21 and 37 μ respectively.

It is also assumed, that the absorption of the alpha-rays in aluminium is proportionate to the absorption in tissue. The 6.7 μ aluminium foil accordingly corresponds to

$$\frac{37}{21} \times 6.7 = 11.8 \ \mu \text{ tissue},$$

9.9	μ	aluminium	corresponds	to	17.4	μ	tissue,
13.6	»	»	»	»	24.0	»	»
16.6	»	»	»	»	29.2	»	»
19.8	»	»	»	»	34.9	»	»
and 21	»	»	»	»	37	»	» .

As the discussion of the exact definition of doses delivered by the different ionizing radiations is still unsettled (PARKER, 1950), the term »roentgen» will be used in this paper. According to LEA (1946), 1 roentgen of 1—5 MeV alpha-rays produces 2,005—1,906 ionizations per 10^{-12} g tissue. An average value of 1.95 ionizations per 10^{-12} g tissue will be used in the following calculations.

The ampère unit is defined as a transfer of one coulomb per second, $= 6.28 \times 10^{18}$ electronic charges per second. The production of one ion-pair may transfer one electronic charge between the electrodes in the ionization chamber. A current of 2.07×10^{-7} ampères (which has been measured using the 6.7 μ Al-foil), accordingly means that at least $2.07 \times 10^{-7} \times 6.28 \times 10^{18} = 13.0 \times 10^{11}$ ion-pairs have been produced per second in the ionization chamber.

Using the 9.9 μ Al-foil, one finds a production of $0.97 \times 10^{-7} \times 6.28 \times 10^{18} = 6.09 \times 10^{11}$ ion-pairs per second in air.

Now 6.7 and 9.9 μ Al correspond to 11.8 and 17.4 μ tissue. In the tissue lying between these values, the volume of which is $(17.4 - 11.8) \times 10^{-4}$ cm $\times$ 1 cm $\times$ 1 cm $= 5.6 \times 10^{-4}$ cm³, $= 5.6 \times 10^{8}$ μ^3, the number of ionizations produced will be $13.0 \times 10^{11} - 6.09 \times 10^{11} = 6.91 \times 10^{11}$ per second, and the average dose in this volume

$$= \frac{6.91 \times 10^{11}}{5.6 \times 10^{8} \times 1.95} = \textit{630 roentgens per second.}$$

In the same way the other doses at the different distances from the surface have been calculated. These doses are shown in fig. 1.

Polonium also emits gamma-rays of very weak intensity, which in these experiments may be quite ignored. From data given in the literature (SIEGBAHN and SLÄTIS, 1946, and PARKER, 1948), it is calculated that the intensity of the gamma-radiation from the polonium preparation is of the order 1 roentgen per hour or less, at the surface of the preparation.

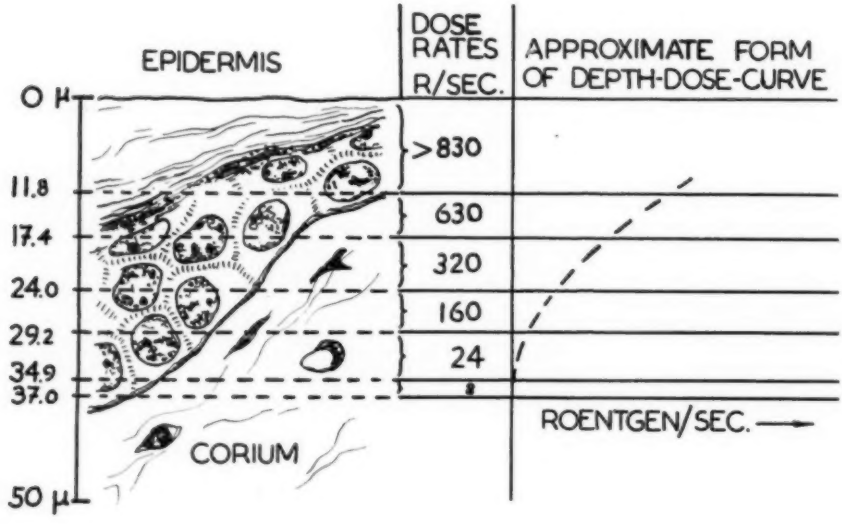

Fig 1. Shows varying thickness of epidermis, dose-rates of alpha-rays at increasing distances from the surface, and approximate form of depth-dose-curve.

During the experiments the decay of the polonium (half-lifetime = 140 days) could not be ignored. The times of irradiation had to be increased up to 33 %. The control measurements of the polonium preparation agreed with the calculated decrease in activity to within 3 %.

The mice during the irradiation were placed in a fairly tight-fitting celluloid cover, with an opening over the back for the polonium preparation. The caudal edge of the irradiated area was stained in the midline with a small spot of Indian ink.

The irradiation times were: 10, 3, and 1 minutes, and 20 and 5 seconds. The corresponding doses are given in Table I.

Histological sections were made after the following intervals: Immediately after irradiation, $^1/_2$ hour, 6, 12, and 24 hours, and 2, 4, 6, 13, and 20 days. Two mice were used for each dose and each interval. (Irradiation for 3 minutes and 20 seconds were omitted for the intervals 12 hours, 24 hours, 4 days, and 13 days.) In all 84 mice were investigated. The general condition remained unchanged after the irradiation.

Table I

Depth-doses at different irradiation times, in roentgens.

	10 min.	3 min.	1 min.	20 sec.	5 sec.	1 sec.
0 μ	> 500 000	> 150 000	> 50 000	> 16 600	> 4 150	> 830
11.8 μ	378 000	113 400	37 800	12 600	3 150	630
17.4 μ	192 000	57 600	19 200	6 400	1 600	320
24.0 μ	96 000	28 800	9 600	3 200	800	160
29.2 μ	14 400	4 320	1 440	480	120	24
34.9 μ	4 800	1 440	480	160	40	8
37 μ						

The animals were killed by cervical luxation. The skin was immediately removed, placed over a small piece of stout paper to prevent too much shrinkage during fixation. Enough skin was removed to get some non-irradiated skin in the sections; in this way every section contained some normal tissue which had been prepared in the same way as the irradiated part, and served as controls.

The skin was fixed for 4 hours in Bouins fluid (containing 2.5 % acetic acid), carefully dehydrated, and embedded by a celloidin-wax method (REVELL, 1949). The sections were cut at 7—8 μ, and stained with hematoxylin-eosin.

Description of the Effects

In the living animals that had been irradiated for 10 minutes the following changes were observed: Half an hour afterwards the irradiated area became slightly pale, whitish. After 6 hours a pale, slightly edematous, sharply outlined square was visible.

The changes increased, until the edema was most pronounced after 48 hours. At this time a faint desquamation could be seen in the area. The desquamation increased after 3 and 4 days, when the edema was subsiding.

After 6 days no increase in the thickness of the skin could be observed; the desquamation had almost stopped, the irradiated skin being somewhat more glossy than the surroundings. Eight days afterwards the irradiated area hardly showed any difference from the surrounding skin. No changes were visible after 14 days, or during the rest of the observation period (20 days).

Only in a few animals was reddening of the skin observed, when the other changes were at their peak. It is, however, difficult to detect any slight hyperemia, because the skin itself has a pinkish hue.

In no animals were blisters or ulcers formed.

The same changes as described above were seen to a lesser degree in

the animals which received the smaller doses. The skin reaction after 3 minutes did not differ very much from that after 10 minutes. One minute irradiation after 1 day caused a slight pallor, which became somewhat more pronounced after 2 days, but then disappeared. A slight difference could be seen for a few days only in the reflexion of the skin.

Some change in the glossiness of the skin could also be observed the second or third day after 20 seconds irradiation, whereas the 5 second dose did not cause any visible changes.

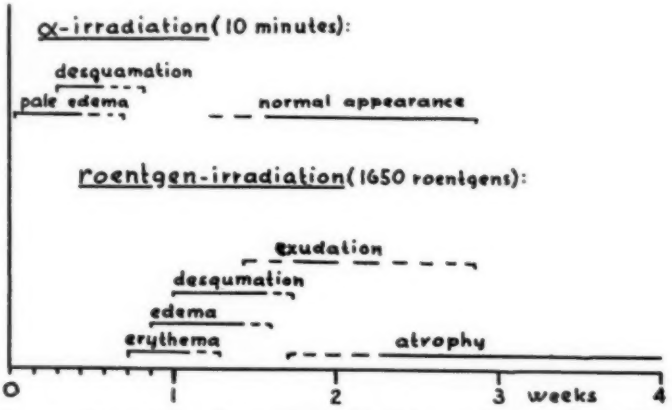

Fig. 2. The visible effects caused by alpha- and roentgen-irradiation.

This skin reaction is quite different from the reaction caused by roentgen rays, which is well known. The roentgen reaction, however, varies considerably in different species and strains. In order to compare some of the effects of the alpha-rays with those of roentgen-rays, some of the hairless mice were treated with doses of roentgen-rays which produced well-marked reactions in the skin.

To avoid constitutional effects of the roentgen-irradiation, a flap of the loose skin of the back of the mice was pulled upwards, and a field 1.5 cm × 1.5 cm got a dose of 1,650 roentgens. (50 KV, 2 mA, 1 mm Al, FSD 22 mm.)

No visible effects appeared until the 5th day, when a slight, well outlined erythema appeared in the exposed area, becoming more distinct the following day, when a moderate edema also appeared. Some desquamation started about the 7th day.

The erythema, edema and desquamation persisted a few days, and in some mice gradually disappeared. Some mice showed a more pronounced reaction, with exudation and formation of crusts, which disappeared in the course of the 3rd week. In all these mice atrophic changes gradually became manifest, with thin, glossy, somewhat shrunken skin in the irradiated area. Fig. 2 illustrates the differences between the visible skin reactions after alpha-irradiation and after roentgen-irradiation.

Histological and Cytological Changes after Alpha-Irradiation

The sections from *the 10-minute-dose series* are being described in some detail.

The sections of the skin fixed immediately after irradiation could not be distinguished from normal epithelium.

Time after irradiation (T) = $^1/_2$ *hour:* No distinct changes in epithelium or connective tissue, except lack of living mitoses in the epidermis; some dead, partly pathological mitoses, and some pycnotic nuclei.

T = *6 hours:* Partly swollen epidermis. Several cells with swollen, vacuolized cytoplasm and nuclei. No normal mitoses; many remnants of pathological mitoses. Some pycnotic nuclei, chiefly in the basal layer of epidermis. The corium is of normal appearance.

T = *12 hours:* Considerably thickened epidermis, owing to swollen, partly vacuolized cytoplasm of the cells, and enlarged nuclei, with reduced stainability. No normal mitoses; many remnants of pathological mitoses. Many pycnotic nuclei, chiefly in the basal layer of epidermis.

There seems to be some edema in the corium; the number of cells also seems to be slightly increased, with a few leucocytes.

T = *24 hours:* Considerable swelling of the epidermis, with an irregular, disorganized structure, and weak staining. The cytoplasm of the cells is rather swollen, the nuclei often enlarged, with clumping of the chromatin, and enlarged nucleoli.

A few mitoses in the basal layer seem to be of normal appearance; many pycnotic nuclei. Some edema of the corium, which also shows a moderate increase of the number of cells (fibroblasts and leucocytes).

T = *48 hours:* Considerably thickened epidermis, the cause of which partly seems to be an increase in the number of cells. The superficial cell layers are more or less separated from the rest of the epidermis. In no place a complete separation of the epidermis from the underlying connective tissue can be seen. Some of the cells have swollen cytoplasm; several of the nuclei are much enlarged, chiefly those nearest the surface; these cells often contain vacuoles, large nucleoli, and the chromatin net is coarse.

Many mitoses of normal appearance in the basal layer. Several remnants of abnormal mitoses. There seems to be some edema, and some increase of the number of cells in the connective tissue.

T = *4 days:* Parts of the epidermis somewhat thickened; the cytoplasm of the cells hardly swollen, with few vacuoles. The nuclei not much enlarged.

Several mitoses of normal appearance in the basal layer; few remnants of abormal mitoses.

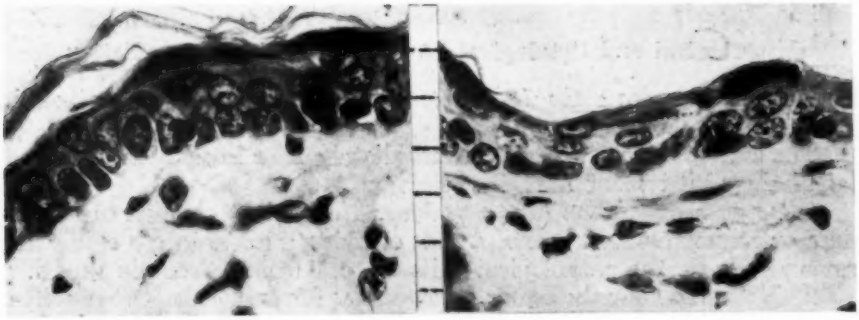

Fig. 3. Fig. 4.

Figs. 3 and 4. Two different sections of normal epidermis. All photomicrographs are of the same magnification, the distance on the scale being 10 μ between each line.

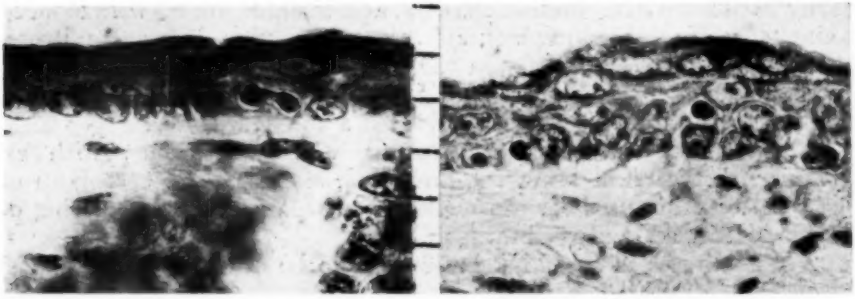

Fig. 5. Ten minutes alpha-irradiation. Time after irradiation (T) = 1/2 hour. One pathological mitosis.

Fig. 6. Ten minutes alpha-irradiation. T = 6 hours. Swollen and pycnotic nuclei.

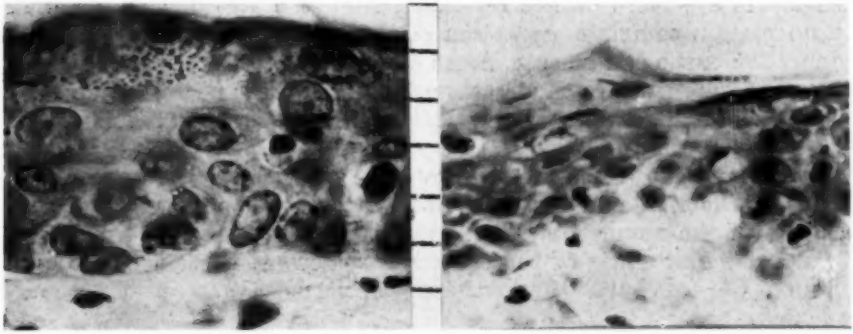

Fig. 7. Ten minutes alpha-irradiation. T = 12 hours. Swollen epidermis.

Fig. 8. Ten minutes alpha-irradiation. T = 24 hours. Disorganized structure. One mitosis of normal appearance.

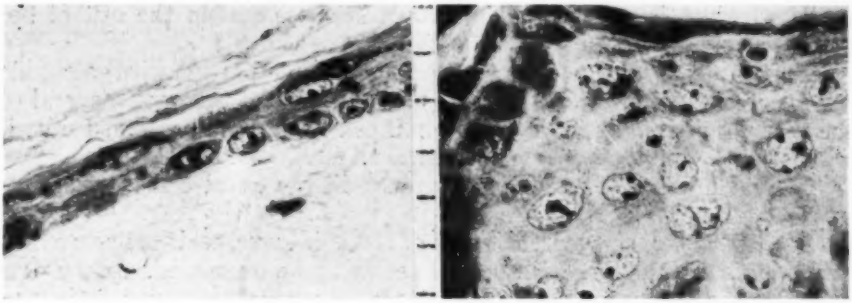

Fig. 9. Fig. 10.

Figs. 9 and 10. Ten minutes alpha-irradiation. T = 6 days. Atrophic and swollen epithelium from the same section.

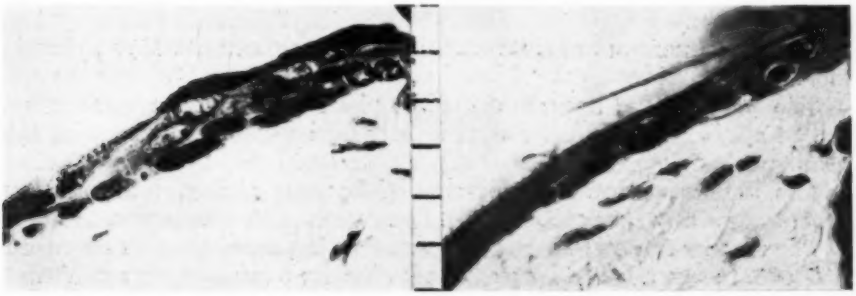

Fig. 11. Ten minutes alpha-irradiation. T = 6 days. Atrophic epidermis.

Fig. 12. Ten minutes alpha-irradiation. T = 20 days. Atrophic epidermis.

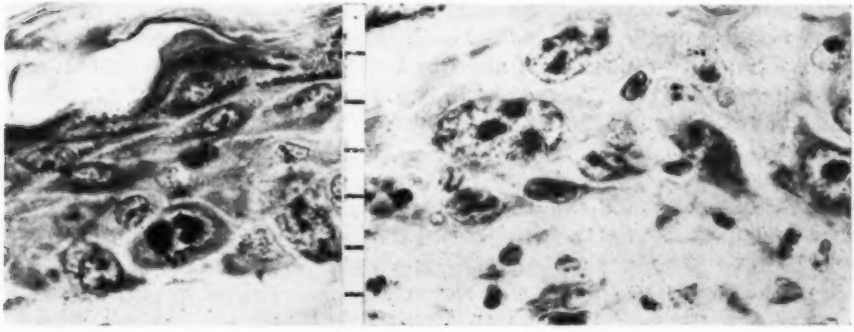

Fig. 13. Roentgen-irradiation, 24 hours after 1,650 r. Swollen epidermis; mitosis with »bridge» and fragments.

Fig. 14. Roentgen-irradiation, 72 hours after 1,650 r. Swollen epidermis; big nuclei with enlarged nucleoli, and several micronuclei.

The corium is of normal appearance in these and in the rest of the sections.

T = 6 days: Epidermis not thickened, but partly with atrophic appearance. Some vacuolization of the cytoplasm of the cells. Several of the nuclei quite small; in the superficial cell layers some enlarged nuclei, with vacuoles and coarse chromatin net.

Several mitoses of normal appearance in the basal cell layer. Some pycnotic nuclei.

T = 13 days: Uneven thickness of the epidermis, which is somewhat atrophic. The amount of cytoplasm seems to be decreased. Only a few nuclei appear enlarged. Several mitoses of normal appearance in the basal layer.

T = 20 days: Epidermis partly a little thickened, but as a whole thinner than in normal sections. Decreased amount of cytoplasm in many cells. Several nuclei of decreased size; coarse chromatin net in some of them.

Mitoses in normal amounts and of normal appearance. Few pycnotic nuclei.

The number and appearance of the blood vessels in the sections described above, did not differ significantly from normal sections, with the technique employed.

The derivatives of the epidermis (sebaceous glands, hair follicles) did not show any changes after the irradiation with alpha-rays.

The smaller doses of alpha-rays produced the same changes described as above, but to a lesser degree. Irradiation for 3 minutes caused almost as marked changes as 10 minutes irradiation.

The changes were significant also after 1 minute irradiation, but the 20- and 5-second doses had a rather slight effect.

The smallest dose seemed only to affect the dividing cells: Similar to the effects of the heavier doses, all the mitoses disappeared for some time, when only remnants of abnormal mitoses, and also pycnotic nuclei were found. In other respects the irradiated area could not be distinguished from normal sections.[1]

The *roentgen irradiation* (*1,650 r*) caused changes in the skin which may be described briefly as follows:

T = 24 hours: Slightly thickened epidermis; some swelling of the cytoplasm in several of the cells, some of the nuclei are enlarged. The few mitoses are mostly abnormal, with »bridges» and fragments.

[1] Note added in proof:

The skin reaction has also been investigated 45, 88, 122, 131 and 164 days after 10 minutes alpha-irradiation (12 animals). The skin of these mice was of normal appearance. In the sections no pathological signs were found, except in two sections taken 88 days and one 131 days after irradiation, where parts of the epidermis seemed to be slightly atrophic.

T = 48 hours: Much the same as after 24 hours. The number of mitoses is increased; some of them seem to be normal. Several cells also contain micronuclei. Slight invasion by leucocytes in the corium, and probably some hyperemia.

T = 3 days: The same as after 48 hours, except some groups of epidermal cells which show marked changes, greatly swollen cytoplasm, with large, faintly staining nuclei, and fairly large nucleoli.

T = 4 days: Many abnormal mitoses. Many cells contain several micronuclei. Some hyperemia. Degenerative changes visible in hair sheaths and sebaceous glands.

T = 7 days: Heavy changes of the epidermis, which often is much thickened. The cytoplasm of the cells is heavily swollen, the nuclei often of monstrous size, faintly staining, and with big nucleoli. Many micronuclei, few mitoses.

In several places the epidermis seems to separate from the connective tissue. Some edema, hyperemia, and increase in number of cells in the corium. Marked degenerative changes in sebaceous glands and hair follicles.

After *14 days* an abnormal, evenly thickened epidermis is found, the individual cells being of almost normal appearance. Several mitoses, which seem to be normal; many pycnotic nuclei. Sebaceous glands and hair follicles almost disappeared. Some edema in the corium.

The picture is not much changed after *22 days*. At *37 days* the epidermis is more normal looking, except for some thin, atrophic parts. There is some regeneration of hair follicles and sebaceous glands.

Discussion

In this paper the alpha-ray dosage is stated in roentgen units, calculated from the ionization in air.

It is well known that physical equivalent doses of alpha- and roentgen-rays may in several ways not cause the same biological response. It has for instance generally been accepted that 1 roentgen alpha-rays corresponds to the biological effects of 10 roentgens gamma- or roentgen-rays, this ratio being used when calculating tolerance doses in the body (PARKER, 1948).

In producing certain cytological effects the alpha-rays may sometimes be more effective, and sometimes less effective than the physical equivalent doses of roentgen-rays (GRAY, 1946).

These facts must be borne in mind when comparing the effects produced by these rays.

As regards the histological and clinical effects produced by these rays, it is generally stated that no qualitative differences can be detected, using any ionizing radiation, including the alpha-radiation (BLOOM, 1947, PROSSER et al., 1947).

Turning to the experiments described in this paper, it is important to know how accurately the calculated alpha-ray doses can be assigned to the cell-layers in the sections:

First, the range in tissue of the alpha-particles from polonium is not accurately known. The reasons for assuming a range of 37 μ in these experiments have been given above.

Second, many uncertainties are connected with the skin preparations. Fixation of the skin causes some shrinkage (18.5 % with Bouins fluid, quoted from ROMEIS, 1943). The skin may not have been stretched to the same degree at fixation, as during irradiation. Also, it cannot be ascertained that every section has been cut exactly vertical to the skin surfaces.

The most important source of error is, however, the superficial fatty secretion from the sebaceous glands, imbibing and covering the epidermis. This fatty layer is dissolved during the staining process, and is not seen in the ordinary sections.

In freshly prepared, non-fixed, frozen sections, stained with sudan and aqueous hematoxylin at room temperature, the fatty layer outside the living epidermal cells can be seen, and is found to vary considerably, from less than 1/3 up to approximately the same thickness as the layer of living epidermal cells. This fatty layer includes the dead and horny epidermal cells, which can be seen also in many of the sections prepared in the usual manner.

For these reasons one cannot accurately tell how deep the alpha-rays have penetrated into the skin.

In the sections the thickness of the epidermis varies from 10 μ or less up to more than 20 μ. Taking into account the above mentioned sources of error, it still may be concluded that the alpha-rays in many places have penetrated the whole epidermis, and a short distance into the connective tissue. This seems to be confirmed by the findings that even the smallest dose employed destroyed the mitoses in the basal layer.

The radiation from the polonium preparation is very intense, and it is possible to give enormous doses in a short time. Between 12 and 17 μ below the surface about 380,000 roentgens will be delivered in 10 minutes, and at a depth between 24 and 29 μ the average dose will be almost 100,000 roentgens during the same time. The basal layer of the epidermis in many places must have received doses of this magnitude. It is therefore striking, that complete separation of the epidermis from the connective tissue was not observed in any animal or any preparation. The desquamation seen after the heaviest doses comprised the superficial cells only.

The mitoses found from 1 or 2 days after the irradiation could not be seen to originate from the hair sheaths or from the ducts of the sebaceous glands, which were beyond the range of the alpha-particles.

It must therefore be concluded, that *the epidermis contains a number of cells which will survive doses of the order 100,000 roentgens of alpha-rays*, and it seems possible that these cells are able to undergo division at a later stage.

The case reported by LARKIN (1941) points in the same direction: A beam of alpha-particles from a cyclotron (32 MeV) hit the dorsum of the hand of one of the scientists by accident. The dose was calculated to be of the order of 70,000 roentgens down to a depth of 1 mm. After 4 hours erythema appeared, and two small blisters the following day. The reaction was of a very long duration, as thickening of the epidermis was still present 4 months later. Desquamation from the 10th day was described, but no loss of the whole epidermis mentioned. Accordingly, it is most likely that many cells have survived doses of the order of 70,000 roentgens.

The discrepancy between a dose of roentgen-rays which gives a local erythematous-exudative skin reaction, and the heavy doses of alpha-rays which cause a less severe reaction in the epidermis, cannot be explained as a result of qualitative differences only.

The alpha-ray doses are one to two orders of magnitude above the roentgen-ray doses, and still the latter give the most pronounced effects in the epidermis.

The roentgen-ray doses may be regarded as uniform throughout the skin, whereas the alpha-ray doses are confined to a superficial layer of about 37 μ in thickness, and hardly affecting more than a small number of the most superficial capillary loops.

Accordingly, the direct radiation effect on the epithelial cells seems to be of minor importance compared with the indirect effects from the underlying connective tissue. These indirect effects most probably are a result of the response of the vascular system to the irradiation, the normal functioning of the »capillary bed» being most important for the tissue metabolism. The literature, however, seems to contain little detailed information about the rôle played by the vascular system in irradiated tissue.

The above findings are consistent with experiments published by UNGAR and WARREN (1937). After irradiation of the ears of rabbits with doses of gamma-rays which invariably caused necrosis of the epithelium when left in situ, irradiated epithelium was transplanted to normal corium and found to be able to grow in 32 % of the transplants. Normal epithelium which was transplanted to the irradiated area always failed to grow.

It has long been known that cells are more resistant when irradiated in vitro than when irradiated in vivo. As an example, it may suffice to quote from SPEAR (1946), »that tissue cultures of avian fibroblasts in some cases may recover after a dose of 18,000 roentgens (gamma-rays)».

Regarding the mitoses in the epidermis, the alpha-rays produced significant effects.

No mitotic activity was observed for 1—2 days after the irradiation, even after the smallest dose.

The first mitoses after a dose of roentgen- or gamma-rays generally show an abnormal appearance, to a certain degree depending on the dose.

Characteristic effects are the formation of »bridges» and chromosome fragments, most easily observed in the telophase (KOLLER, 1947). Cells containing micronuclei may become quite abundant, and are regarded as cells that have been formed from pathological mitoses after the time of irradiation. The sections from the mice of the roentgen-ray-series contained numerous cells with these changes (figs. 13 and 14).

These effects were only occasionally observed after the alpha-irradiation. Most of the abnormal mitoses in these preparations seemed to have been dead at the time of fixation.

Every dose of alpha-rays caused an increase in the number of pycnotic nuclei. Many of these, often fragmented, seemed to be the remnants of cells in mitosis. One got the impression, that most of the pycnotic nuclei had originated from cells that had been lethally injured at some stage in the process of mitosis.

The living mitoses that were observed from the 2nd day onward were of normal appearance. Micronuclei were found only occasionally.

Some of the common irradiation effects were lacking after the external alpha-irradiation. In spite of the marked changes of the epithelium, the underlying connective tissue usually was of normal appearance. There seemed to be some increase in the number of cells, and a slight edema of the corium in a few sections only. The epidermis itself never was invaded by leucocytes.

Although the histological sections usually give poor information as regards the blood vessels, it may be noted that neither the number of the blood vessels, nor their appearance showed any significant difference from those in the normal sections.

The fact, that even the connective tissue adjacent to severely injured parts of the epidermis, as well as the epithelial derivatives did not show any appreciably pathological changes, may indicate that the irradiation effects in the epidermis do not involve production in noticeable amounts of freely diffusible toxic substances.

Conclusion

The histological and cytological effects of alpha-rays from polonium on the skin of mice have been investigated in 84 mice from a recessive hairless strain, the experiments comprising 5 different irradiation doses, at intervals up to 20 days after the irradiation. In the experiments the range of the alpha-particles is assumed to be 37 μ in tissue, which represents more than the thickness of the epidermis.

The ionization caused by the alpha-particles from the polonium

preparation (10 millicuries Po spread on a square nickel sheet, 1 cm^2), has been determined in an ionization chamber, screening the preparation by aluminium foils of varying thickness. From these observations the different depth-doses have been calculated, and expressed in roentgen units.

In the same strain of mice the effects of a dose of roentgen-rays causing a marked local skin reaction (1,650 r) have been briefly described.

It is found, that many of the cells in the epidermis will survive doses of the order of 100,000 roentgens (alpha-rays).

The effects of alpha-irradiation have been compared to the effects of roentgen-irradiation. The »indirect effects» brought about by the connective tissue seem to be of major importance to the skin reaction after roentgen-irradiation.

The mitotic activity is suppressed for 1—2 days after the alpha-ray doses. The characteristic cytological changes seen in mitosis after roentgen-irradiation — viz. chromosome fragments, »bridges», and cells with micronuclei — were only occasionally observed after the alpha-irradiation.

The heavy doses of alpha-irradiation administered to the epidermis probably do not cause production of freely diffusible toxic substances in any noticeable amounts.

SUMMARY

The article describes the histological and cytological changes in the skin of mice from a hairless strain, after external alpha-irradiation. It is found, that the epidermis contains cells, which are able to survive doses of the order of 100,000 r.

The effects of the alpha-rays, which mainly are localized to the epidermis, have been compared to the effects caused by roentgen-rays in the skin. This comparison stresses the great importance of the »indirect effects» brought about by the stroma-vascular bed, when the latter also is irradiated.

ZUSAMMENFASSUNG

Die Abhandlung beschreibt die histologischen und cytologischen Veränderungen in der Haut von Mäusen einer haarlosen Art nach äusserlicher Behandlung mit Alpha-Strahlen. Man hat festgestellt, dass die Epidermis Zellen enthält, die Dosen von der Grösse von 100,000 r überleben.

Der Effekt der Alpha-Strahlen, der hauptsächlich in der Epidermis auftritt, wird mit dem Effekt der Röntgenstrahlen in der Haut verglichen. Dieser Vergleich betont die grosse Bedeutung des »indirekten Effekts», der hervorgerufen wird durch das stroma-vasculäre Bett, wenn dieses auch bestrahlt wird.

RÉSUMÉ

L'article décrit les altérations histologiques et cytologiques dans la peau de souris d'une espèce chauve à une irradiation externe de rayons alpha. Il est constaté que l'épiderme contient des cellules capables de survivre à des doses de l'ordre de 100,000 r.

Les effets des rayons alpha qui se localisent essentiellement à l'épiderme ont été comparés aux effets causes par les rayons roentgen sur la peau. La comparaison fait ressortir la grande importance des »effets indirects» provoqués au niveau de la trame vasculaire quand celle-ci aussi est irradiée.

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ÜBER DIE RÖNTGENDIAGNOSE DES ZWEIHÖHLENSCHUSSES[1]

(Zwerchfellverletzung ohne Intestinalprolaps)

von

R. Haubrich

Während grosse Zwerchfellrisse durch stumpfe Gewalt oder grobe Schussverletzungen ein schweres klinisches Bild bedingen und bei erheblichen abdominellen Erscheinungen mit oder ohne Prolaps von Bauchorganen in die Pleurahöhle leicht erkennbar sind, bleiben kleinere Schussverletzungen des Zwerchfells meist unerkannt. Nach LANDOIS ist die Diagnose des unkomplizierten kleinen Zwerchfelloches unmöglich, weil derartige Verletzungen völlig symptomlos verlaufen; die Zwerchfellatmung braucht nicht behindert zu sein, und eine Bauchdeckenspannung fehlt in den meisten Fällen. So ist es erklärlich, dass fast alle unkomplizierten Schussverletzungen des Zwerchfells dem Nachweis entgehen, erst bei einer Thorakotomie gefunden werden oder sich sehr viel später aus der Rekonstruktion des Schussverlaufes eines Steckgeschosses nur nachträglich feststellen lassen.

Die klinische Symptomatologie der Zwerchfellverletzung ist sehr arm, solange ein Prolaps nicht eintritt und solange stärkere abdominelle Symptome fehlen. Ein Vorfall von Netz aus der Thoraxwunde (SUTER, ISELIN) kommt nur bei grossen Zwerchfelldefekten vor, wo es eines solch eindeutigen Symptoms bei der Schwere des Krankheitszustandes zur Diagnose ohnedies kaum bedarf. Ein Netzprolaps lediglich in die Zwerchfellwunde ist diagnostisch kaum zu fassen und wird — falls eine Thorakotomie nicht erfolgt — vielfach erst auf Grund der stark verzögerten Heilung vermutet werden können (NAEGELI). Fällt weder ein Intestinalorgan noch das Netz in die Zwerchfellwunde vor, dann heilt das Zwerchfell glatt und schnell ab, wie ISELIN experimentell gezeigt hat und wie es schon aus den Erfahrungen der frühreren Zeit an Schuss- und Stichverletzten bekannt war (MAGULA). Dies gilt allerdings nur für die peripheren Zwerchfellöcher; mehr zentrale Wunden, vor allem auch der Zwerchfellkuppe, heilen wesentlich schlechter, zumal hier die Prolapsgefahr auch ungleich grösser ist.

[1] Bei der Red. am 17 Okt. 1950 eingegangen.

Eine ausserordentliche Bereicherung der Diagnostik der Zweihöhlenschüsse, insbesondere der Symptomatologie der unkomplizierten kleinen Zwerchfellverletzung, ist mit der Röntgenuntersuchung gewonnen, wie im Folgenden gezeigt wird. Erst im letzten Weltkrieg bestand die Möglichkeit, in grösserem Unfang auch Verwundete mit Zweihöhlenschüssen röntgenologisch zu untersuchen. Die für die Diagnostik der bisher fast immer unerkannten kleinen und unkomplizierten Zwerchfellverletzung gesammelten Erfahrungen sollen an typischen Beispielen aus einem grösseren Beobachtungsmaterial wiedergegeben werden.

I. Zweihöhlenschüsse mit Pneumoperitoneum

Fall 1. Ba. — Verwundung am 18. 10. 43. Einlieferung am 21. 10. 43. Nach mitgebrachten Krankenpapieren und Aussage des Verletzten in der Zwischenzeit keine entzündlichen Bauchsymptome; Essen und Stulgang normal. — *Klinisch:* Bei subjektiv sehr gutem Zustand besteht ein Beklemmungsgefühl in Brust und Bauch. Tympanie über dem weichen Abdomen. Keine peritonitischen Erscheinungen. Klopfschallverkürzung über der ganzen linken Thoraxseite. Einschuss am li. Rücken, 1—2 Handbreit unter dem Schulterblatt, Ausschuss li. vorne unter dem Rippenbogen. Keine Rippenfraktur. — *Röntgenbefund:* Massive Verschattung über der ganzen li. Lunge bei starker Rechtsverdrängung des Herzens, re. Lunge frei. Beide Zwerchfellhälften sind als scharf begrenzte Bogenlinien sichtbar; der obere Leberrand ist durch eine gut handbreite und bei Lagewechsel verschiebliche Luftsichel vom re. Zwerchfell getrennt. Ähnliche grosse Luftsichel li., Luftansammlung auch unter dem diaphragmalen Herzbett.

An der Diagnose eines Zweihöhlenschusses mit Zwerchfellverletzung ist nach dem Röntgenbild nicht zu zweifeln. Die Diskrepanz zwischen dem massiven röntgenologischen Befund des riesigen Pneumoperitoneums bei grossem Haematothorax und dem klinisch wenig schweren Zustandsbild ist eindrucksvoll genug. Sie wird unterstrichen mit dem Hinweis, dass jegliche peritonitischen Anzeichen umschriebener oder diffuser Art fehlten und auch während der ganzen Beobachtungszeit nicht auftraten. Der Patient verlor nach mehrmaliger Punktion der Pleurablutung — eine Peritonealpunktion zur Entfernung der Luft oder wenigstens Druckminderung wurde vom Chirurgen abgelehnt — langsam das Beklemmungsgefühl; die Darmtätigkeit blieb völlig störungsfrei. Nach relativ kurzer Zeit konnte Verlegung in ein rückwärtiges Lazarett erfolgen, wo der Patient sich unter Behandlung ausschliesslich der Thoraxverletzung rasch erholte.

Die wichtige Frage, woher die Luft in der freien Bauchhöhle stammt, ist nicht leicht zu entscheiden. Dass sie etwa von aussen mitgerissen oder nachgeströmt ist, scheidet nach der Schussrichtung und vor allem bei der Grösse des Pneumoperitoneums ganz aus; es ist bekannt, dass immer nur wenige und kleine Luftblasen durch eine Einschuss- oder Ausschusswunde eindringen. Die naheliegende Erklärung, die Peritonealluft stam-

me aus einem mitdurchschossenen lufthaltigen Bauchorgan, und der Befund der beiderseitigen Luftsichel unter dem Zwerchfell entspräche entstehungsmechanisch etwa dem Pneumoperitoneum nach einer Ulcusperforation, ist aus mehrfachen Gründen nicht stichhaltig. Nach dem Schussverlauf ist eine mehr zentrale Verletzung des Zwerchfells unmöglich; sehr wahrscheinlich lag eine periphere vordere Verletzung vor (Ausschuss in der Mamillarlinie unter dem Rippenbogen). Danach muss der Schuss links am Magen und oberhalb der linken Colonflexur vorbeigegangen sein. Diese Annahme wird nachdrücklich unterstützt durch die Tatsache, dass keinerlei lokale abdominelle Erscheinungen auftraten, und vor allem durch die chirurgische Erfahrung, dass eine Perforation des Magens oder gar des Darmes unter dem beschriebenen unauffälligen Bild nicht denkbar ist. So bleibt nur die Erklärung, dass es sich bei dem Pneumoperitoneum um Luft handelt, die aus der gleichzeitig verletzten Lunge stammt und durch den Zwerchfelldefekt in den Bauchraum gelangt ist. Dieser Entstehungsmodus setzt voraus, dass unmittelbar im Anschluss an die Lungenverletzung ein Pneumohaematothorax vorhanden war, der unter erheblichem Überdruck stand und bei horizontaler Körperlage durch den frischen Zwerchfellriss in Austausch mit der Bauchhöhle treten konnte; diese Luftverlagerung dürfte durch den Zwerchfellkrampf (die auch experimentell nachgewiesene Sofortreaktion gerade beim peripheren Riss) und die folgende Pressatmung nur gefördert werden. Da der Patient erst drei Tage nach seiner Verwundung untersucht werden konnte, brauchte der Pneumothorax nicht mehr nachweisbar zu sein. Angesichts der erheblichen Herzverlagerung zur gesunden Seite noch bei der Aufnahme und späterhin ist erklärlich, dass bei dem starken pleuralen Überdruck keine Lungenluft mehr in den Pleuraraum nachgeströmt ist; eine Rückströmung aus dem Abdomen zum Pleuraraum ist bei rascher Verklebung der Zwerchfellwunde gleichfalls verhindert.

Es sei zugestanden, dass dieser Entstehungsmechanismus des Pneumoperitoneums uns anfangs kaum glaubhaft erschien, zumal dieser Fall unsere erste derartige Beobachtung darstellte. Da aber später fünf weitere Fälle von Pneumo-(haemato-)peritoneum bei Zweihöhlenschüssen beobachtet werden konnten, wo ein klinischer Anhalt für die Verletzung eines lufthaltigen Intestinalorganes stets fehlte, halten wir diesen »pulmonalen« Entstehungsmechanismus des Pneumoperitoneums für genügend gesichert. Die Wiedergabe eines weiteren, entsprechenden Falles mag diese Annahme unterstützen; ausserdem aber wird damit demonstriert, wie entscheidend die Röntgenuntersuchung gerade in den Fällen mit glattem und unkompliziertem Zwerchfelldurchschuss wird, in denen die klinische Symptomatologie nur dürftig sein kann.

Fall 2. Er. — Verwundung am 6. 3. 45, Aufnahme am 8. 3. 45. — *Klinisch:* Subjektiv völlig beschwerdefrei. Kein Fieber, kein Husten; Essen und Stuhlgang normal,

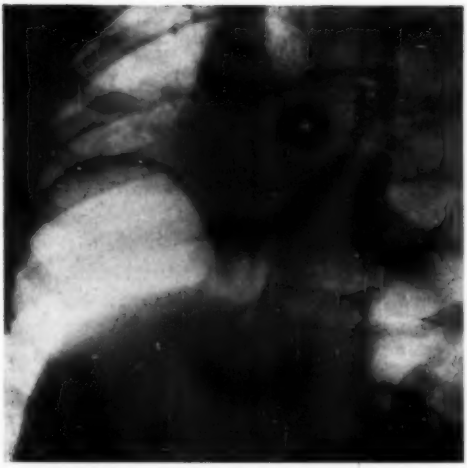

Abb. 1. Zweihöhlenschuss mit grossem Pneumoperitoneum und Haematothorax links (periphere Zwerchfellverletzung links vorn).

Abb. 2. Kleines Pneumohaematoperitoneum und Haematothorax links basal (peripherer Zwerchfellschuss links).

kein Blut im Stuhl. Lokal: Einschuss an der vorderen Rumpfwand, wenig seitlich der Mamillarlinie unter dem li. Rippenbogen; Ausschuss an der li. Rückenseite dicht unterhalb des Schulterblattwinkels. Fragliche Schallverkürzung über der dorsalen Lungenbasis li. Abdomen weich. — *Röntgenbefund:* Verschattung des li. Sinus phrenico-cost., vor allem dorsal und nach oben. Sichelförmige schmale Luftaufhellungen unter beiden Zwerchfellhälften, re. über einem kleinen Flüssigkeitsspiegel (Abb. 2). Lungen sonst frei, Herz o. B. — Kontrolle am 15. 3. 45: Thorax und Abdomen röntg. o. B. Völlige Resorption des Pleuraergusses und der Peritonealluft. — Bei subjektiv weiter ungestörtem Befinden Verlegung in ein rückwärtiges Lazarett am 25. 3. 45.

Danach handelt es sich um einen unkomplizierten glatten Zwerchfellschuss (Zweihöhlenverletzung) mit kleinem basalem Haematothorax links und Pneumohaematoperitoneum; der kleine Flüssigkeitsspiegel in Abb. 2 ist ja demonstrativ. Nach dem Schussverlauf, der praktisch identisch mit dem nur in umgekehrter Richtung verlaufenden Durchschuss bei ersten Fall ist, muss auch hier eine periphere ventrale Verletzung des linken Zwerchfells angenommen werden. Bei diesem Schussverlauf ist schon topographisch eine Magen- oder gar Dickdarmverletzung ausgeschlossen, ebenso fehlt auch in diesem Fall jeder klinische Anhalt für die gleichzeitige Verletzung eines lufthaltigen Intestinalorgans; der Verwundete, ein knapp zwanzigjähriger Offizier, kam zu Fuss zur Untersuchung und liess sich beim Fehlen jeglicher subjektiver Beschwerden kaum überzeugen, dass er nicht voll einsatzfähig sei. Auch hier handelt es sich bei der Luft des Pneumoperitoneums um Atemluft, die von

der Lungenverletzung herrührt; auch hier ist anzunehmen, dass unmittelbar nach der Verwundung ein freier Pneumothorax bestanden hat, der zwei Tage später nicht mehr nachweisbar war; auch hier muss sich der periphere und vielleicht sogar an der Insertion lokalisierte tangentiale Zwerchfellriss nach dem Luftübertritt ins Abdomen rasch geschlossen haben (aus dem Röntgensymptom der fehlenden freien Verbindung zwischen der grösseren Luftsichel rechts und dem kleineren Luftdepot links kann eine auch subdiaphragmal ausgiebige Verklebung angenommen werden). Natürlich ist immer einzuwenden, dass für diese Folgerungen noch der bioptische Ausschluss einer Intestinalverletzung notwendig ist; trotzdem halten wir sie nach dem Gesagten aus topographischen und klinischen Gründen für schlüssig.

Beim nächsten Fall handelt es sich gleichfalls um eine Schussverletzung des Zwerchfells mit Pneumoperitoneum; vor den ersten beiden Beispielen ist er jedoch dadurch ausgezeichnet, dass die röntgenologische Darstellung der Zwerchfellverletzung selbst und der reparierenden adhaesiven Verklebung unmittelbar gelingt.

Fall 3. Wo. — Nach Krankenbegleitpapier: Am 1. 4. 45 Verwundung, M. P. Steckschuss in der li. Brustwand. Fraktur mehrerer Rippen, Wunde am Schulterblatt oben. Auf dem Hauptverbandsplatz Wundexcision und Verfolg des Schusskanals, der die 11. Rippe durchschlagen hat und »extraperitoneal und -pleural» zur li. Schulterblattgegend verläuft; Entfernung des Geschosses von einer Incision im Bereich der li. Skapula. — Aufnahme am 8. 4. 45. *Klinisch:* Lokal: In der Mamillarlinie li. direkt unter dem Rippenbogen beginnend, findet sich eine senkrechte, 10 cm lange Weichteilwunde, die im oberen Anteil genäht und im unteren offen ist; hier dünne eitrige Sekretion. Am Rücken, in der mittleren li. Skapularlinie schräg gestellte, tief reichende drainierte Wunde. In der Umgebung Schwellung und blutige Verfärbung. Brustorgane: Klin. o. B. Klin. Diagnose: Brustbauchwandsteckschuss (entfernt) mit Beteiligung des subphrenischen Raumes. Thoraxorgane o. B. — *Röntgenbefund:* Leichte pleurale Verschattung der li. Lunge, bes. deutlich im 1. Schrägen. Einschränkung der Beweglichkeit des li. Zwerchfells, das durch eine subphrenische sichelartige Gasansammlung hochgedrängt ist; gute Abgrenzbarkeit dieses Gasdepots gegen Magenblase und Darm (Kontrolle durch Bleischluck). Seitlich unten an der Gassichel kleiner Flüssigkeitsspiegel. Dicht darüber Fraktur der 8. Rippe lateral. Oberhalb davon länglich-dreieckige Verschattung durch *tangential getroffene Duplikatur des Zwerchfellansatzes* (Abb. 3). Im 2. Schrägen auch rechts kleine Luftsichel, dorsal medial zwischen Zwerchfell und Leber; bei Lageänderung des Pat. kein Luftpendeln zwischen re. und li.

Nach der ersten Diagnose war hier ein extraperitonealer und -pleuraler, nach der zweiten chirurgischen Diagnose ein extrapleuraler Rumpfwandsteckschuss mit Beteiligung des subphrenischen Raumes angenommen worden. Da wiederum gar kein klinischer Anhalt für die Eröffnung eines gashaltigen Bauchorgans bestand, bleibt zur Erklärung des Pneumoperitoneums auch hier nur die Annahme einer Zwerchfellwunde bei gleichzeitiger Lungenverletzung. Der gegenüber den beiden ersten Fällen nur geringe Pleurabefund (Haematothorax) ist bei dem 7-tägigen Inter-

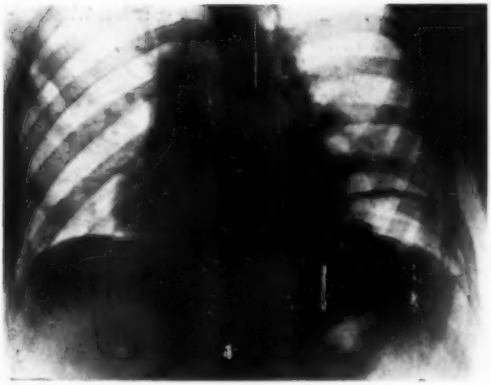

Abb. 3. Partiell abgekammertes, seitenungleiches Pneumoperitoneum durch Zweihöhlenschuss. Zwerchfellabriss links lateral noch sichtbar.

vall zwischen Verwundung und Röntgenuntersuchung verständlich. Es zeigt sich auch an diesem Beispiel, dass beim nichteitrigen Zweihöhlenschuss offenbar die Pleuraluft schneller resorbiert wird als die Peritonealluft. Dass eine Lungenverletzung vorher nicht angenommen wurde, unterstreicht nur die immer wieder feststellbare Diskrepanz zwischen der klinischen Symptomenarmut und der Eindeutigkeit des Röntgenbefundes; denn es kann nach Abb. 3 kein Zweifel daran bestehen, dass gleichzeitig mit der Schussfrakturierung der 8. Rippe auch ein Abriss des Zwerchfells an der lateralen Insertion stattgefunden hat. Die Duplikatur des hier im Röntgenbild frei dargestellten linken Zwerchfells ist nicht zu übersehen; sie dürfte durch eine adhaesive Verklebung bzw. durch entzündliche Auflagerungen bedingt sein. Zusammen mit dem Verlust der Fluktuabilität und Kommunikation der Luftdepots rechts und links verdeutlicht dieser Teilbefund eine dem Zeitintervall von sieben Tagen entsprechende Reparationsphase der Zwerchfellverletzung, die sich im wesentlichen im subphrenischen Raum abspielt.

Im Zusammenhang mit der auffallenden Flüchtigkeit der »subphrenischen» Röntgensymptome der anderen Fälle wird dadurch erklärlich, warum die kleinen peripheren und unkomplizierten Schussverletzungen des Zwerchfells vor der Röntgenaera dem Nachweis entgehen mussten. Es kann ausserdem aber aus diesen Befunden geschlossen werden, dass als Rest- oder Folgezustand solcher Zwerchfellverletzungen lediglich eine mehr oder weniger umschriebene Verschwielung der peritonealen Unterseite und der pleuralen Oberseite des Zwerchfells zu erwarten ist. Dass derartige Schwielenbildungen in der Tat fast immer das auch in späteren Jahren allein noch fassbare Symptom der Zwerchfellverletzung darstellen, konnte bisher nicht direkt nachgewiesen werden. Doch ist dieser Nachweis möglich, wie später noch dargelegt werden kann.

II. Zweihöhlenschüsse mit Pneumothorax und entzündlichen Abdominalprozessen

War im vorigen der Befund eines Pneumoperitoneums entstehungsmechanisch auf eine Lungenverletzung zurückzuführen, obwohl ein Pneumothorax nicht mehr nachgewiesen werden konnte — eine nur scheinbar paradoxe Annahme, wie zu zeigen war! —, so bieten auch die folgenden Beispiele von Zwerchfellverletzung bei Zweihöhlenschüssen Röntgenbefunde, die nur auf den ersten Blick seltsam erscheinen. Es handelt sich um Fälle, bei denen die röntgenologischen Lungen- bzw. Pleuraveränderungen ungleich augenfälliger sind, obschon jeweils sichere schwere Alterationen gerade im Abdomen das Krankheitsbild beherrschen. Die scheinbare Paradoxie in der Symptomatologie auch dieser Gruppe besteht darin, dass hier zwar ein Pneumothorax nachweisbar ist, die peritoneale Gasansammlung bzw. die im Vordergrund stehende Entzündung entstehungsmechanisch davon aber unabhängig ist. Einige Beispiele mögen dies veranschaulichen; eine eingehende Erörterung der als bekannt vorausgesetzten Differentialdiagnostik paraphrenischer Gasansammlungen erübrigt sich hier.

Fall 4. De. — Verwundung am 1. 4. 45 durch Granatsplitter an der re. Bauch- und Rückenseite. Nach Begleitpapieren offener Pneumothorax und Peritonitis. Wundexcision und Pneuverschluss auf dem Hauptverbandplatz. *Klinischer Befund* (8. 4. 45): Schlechter A. Z. — Lokal: am unteren Ende der BWS pfenniggrosser, überkrusteter Einschuss. Ausgedehnte subkutane, weiche teigige Schwellung über der ganzen re. Flanke bis zum Nabel. Re. am Rippenbogen 10 cm lange Hautnaht mit eingelegtem Drain. Perkutorisch re. Schachtelton. Klin. Diagn.: Stecksplitter am Rücken, Pneumothorax, Weichteilphlegmone, subphrenischer Abscess. — *Röntgen:* Das re. Zwerchfell ist durch eine nichttypisch kalottenförmige Gasaufhellung vom oberen Leberrand getrennt, steht hoch und ist völlig unbeweglich. Verschattung des Sinus phrenicocost. Partieller Spitzenpneu re. bei älteren tbc. Herden im Oberfeld. Zwerchfellauszipfelungen und Herzrandausziehung li. Metallsplitter an das li. Schulterblatt projiziert. Subkutane Gasbildung an der ganzen re. Thoraxwand; tiefgelegene Luftinfiltrierung der Weichteile an der seitlichen Bauchwand re. — *Klin. Verlauf:* Spaltung der Wunde am Rücken, Entleerung umfangreicher stinkender Blutkoagula und Gewebsfetzen; die weitere Wundrevision ergibt eine Eröffnung des subphrenischen Raumes. Drainage. Bluttransfusion. 10. 4.: nur geringe Nachblutung; Befund gebessert.

Hier besteht ein durch alte tbc.-pleuritische Verwachsungen nur inkompletter Pneumohaematothorax rechts, dem ein Unterhautemphysem der Thoraxwand korrespondiert; der gleichzeitig bestehenden, gashaltigen subphrenischen Eiterung entspricht eine gashaltige tiefe Phlegmone der Bauchwand (zur Differentialdiagnostik der Gasbildung im Gewebe s. auch HAUBRICH). Die Rekonstruktion des Schussverlaufes ist bei dieser Splitterverwundung nicht sicher möglich, doch muss eine Zwerchfellperforation auch hier als wahrscheinlich angesehen werden. Sie ist in dem einwöchigen Intervall zwischen Verwundung und Röntgenunter-

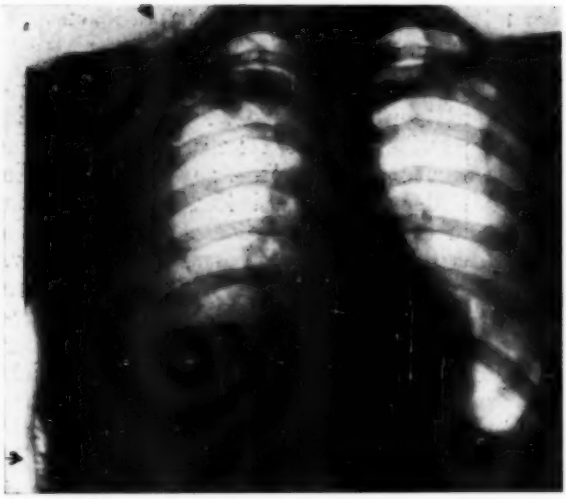

Abb. 4. Kleiner inkompletter Pneumohaematothorax rechts mit Brustwandemphysem. Subphrenischer Gasabszess mit gashaltiger Phlegmone der Bauchwand.

suchung geschlossen, was aus dem Abschluss des eitrigen Abdominalprozesses und der gashaltigen Phlegmone der benachbarten Bauchwand gegen den nicht infizierten Pleuraprozess und das blande Thoraxwandemphysem hervorgeht, und was nach den mitgeteilten Erfahrungen an linksseitigen Zwerchfellverletzungen auch zu erwarten ist.

Wie schwierig trotz scheinbar sicherer röntgenologischer Symptome die Diagnose eines Zweihöhlenschusses sein kann, geht aus dem folgenden Beispiel hervor. Hier bestand zwei Tage nach der Verwundung ein massiver Haematothorax rechts, der 17 Tage p. l. unter doppelter Spiegelbildung schon gut zurückgegangen war (mehrfach abgesackter Pneumohaematothorax). Da bei einer einzigen Schusswunde ausser einem Stecksplitter an der Lungenbasis auch ein Lebersteckssplitter nachzuweisen war, muss ein Zweihöhlenschuss mit Zwerchfellverletzung angenommen werden. Der Einschuss in der Axillarlinie mit Fraktur der 9. Rippe und die Lage der Stecksplitter (Abb. 5 a u. b) im medialen Leberanteil und an der herznahen Lungenbasis lassen einen Schussverlauf rekonstruieren, der das rechte Zwerchfell etwa an der lateralen Insertion getroffen haben und z. T. tangential gerichtet sein müssen. Es ist gut verständlich, dass die Voraussetzungen für eine intraperitoneale Luftverschleppung aus dem Pleuraraum infolge des »Leberabschlusses» hier ungleich schlechter sind als bei linksseitiger Zwerchfelläsion. Dazu kommt, dass nach der Splitterlokalisation vielleicht noch ein weiteres, mehr zentral gelegenes Zwerchfelloch bestand. Diese beiden Faktoren erklären das Fehlen eines Pneumoperitoneums genügend. Mehr am Rande sei vermerkt, dass die

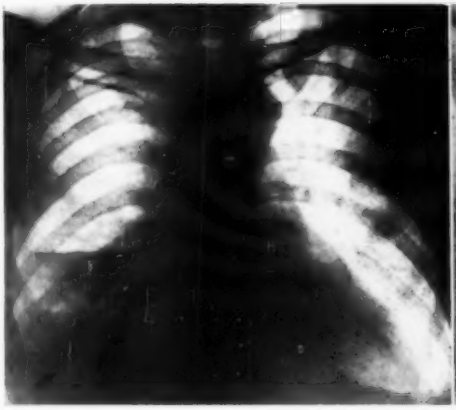

Abb. 5 a. Abgekammerter Pneumohaematothorax (17 Tage p. l) bei Zweihöhlenschuss. Stecksplitter an der Lungenbasis und in der Leber.

Abb. 5 b. Gleicher Fall, 19 Tage p. l. — noch basaler Pneumo-(haemato-) Thorax.

Luftsichel der Abb. 5 b weder ein Pneumoperitoneum, noch einen subphrenischen Gasabscess, sondern einen basal abgekammerten Pneumothorax darstellt; ein Zeichen für die schwierige Deutung dieser paraphrenischen Gasansammlungen zur Diagnostik der Zwerchfellverletzung.

III. Rumpfwandtangentialschüsse mit Zwerchfellabriss

Der letzte Fall steht als Beispiel für die reinen Rumpfwand-Tangentialschüsse, wo unter Aufreissung der unteren Thoraxwand der Zwerchfellansatz abgerissen wird (LANDOIS, PERTHES-LÄWEN). Er demonstriert ausserdem die Verbindung der röntgenologischen Merkmale des subphrenischen Abscesses und des abgekammerten artefiziellen Pneumoperitoneums, bei gleichzeitigem Haematothorax.

Es handelte sich nach der Erstdiagnose um einen »Brusttangentialschuss rechts mit Rippenfraktur, ohne Pleuraverletzung». Die Röntgenuntersuchung am 8. Tage p. l. zeigt aber eine massive Ergussverschattung der rechten Lunge, dazu einen Leber- oder subphrenischen Abscess mit Spiegelbildung und eine kleine Luftsichel am medialen Zwerchfellanteil, die erst nach der Abscessdrainage mittels Rippenresektion auftrat und als entzündlich abgekammertes Pneumoperitoneum nicht verschieblich war. Einschuss und Ausschuss waren nur zweihandbreit voneinander entfernt; es lag ein Abriss des Zwerchfellansatzes vor, wie sich auch nach mehreren Tagen noch aus dem enormen Hochstand des lateralen Zwerch-

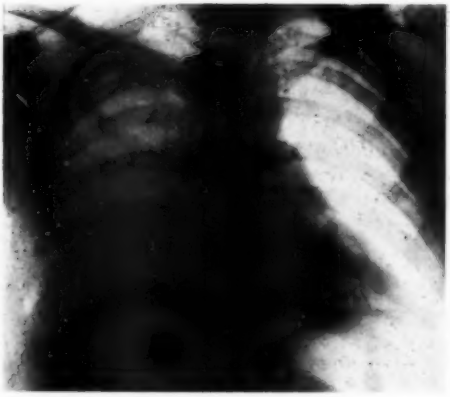

Abb. 6. Brustwandtangentialschuss mit Haematothorax, subphrenischem Abscess und abgesacktem Pneumoperitoneum rechts (8 Tage p. l.).

fellteils ergab. Ein Prolaps des Zwerchfells oder eines Bauchorgans in die grosse äussere Wunde, wie er bei diesen Verletzungen als häufig beschrieben ist, bestand nicht. Auch dieser Patient konnte fieberfrei und ausser Gefahr nach wenigen Wochen verlegt werden.

Es ergibt sich hieraus, dass in allen wiedergegebenen Fällen die Zwerchfellverletzung ausserordentlich rasch abheilte; auch von unserem übrigen Material ging nur ein Fall mit zentraler Schussperforation des Zwerchfells verloren. Damit werden die früheren Erfahrungen über die gute Prognose vor allem der unkomplizierten peripheren Zwerchfellschüsse bestätigt und insofern noch erweitert, als eine überraschend gute Heilungstendenz sich auch trotz Komplikation durch einen Haematothorax und z. T. auch durch subphrenische Eiterungen ergibt, im Gegensatz zur bisherigen Anschauung (Naegeli). Zum anderen geht aus dieser Zusammenstellung hervor, welcher Fortschritt in der Diagnostik der akuten Zwerchfellverletzung röntgenologisch erzielbar ist. Und nur die Röntgenuntersuchung ist zudem in der Lage, auch die klinisch weitgehend symptomfreien Folgezustände der unkomplizierten Zwerchfellverletzung objektiv zu fixieren, wie im Folgenden auszuführen ist.

IV. Spätbefunde nach Zwerchfellschussverletzungen

Es ist schon eingangs darauf hingewiesen, dass eine nichtoperative Sofortdiagnose der unkomplizierten Zwerchfellverletzung bisher mangels genügender Symptome unmöglich war. Als Spätdiagnose konnten Zwerchfelläsionen nur durch die Rekonstruktion des Schussverlaufes wahrscheinlich gemacht oder z. B. dann gesichert werden, wenn ein abdominelles Steckgeschoss bei einer einzigen Einschussnarbe an der Thoraxwand zu finden war. Die Spätdiagnose eines Zwerchfellschusses aus einer

Abb. 7. Zentrale Zwerchfellvernarbung. Zweihöhlenschuss vor 35 Jahren. (Systolisches Zwerchfellzucken links medial, Zwerchfellausziehung rechts medial.)

Zwerchfellhernie (LIEBERMEISTER, RIEDER, HAUBRICH u. a.) bleibt im Rahmen des Themas ausser Betracht. Der Nachweis einer seitlichen Zwerchfelladhaesion als Zeichen der diaphragmalen Schwielenbildung bedeutet für diese Spätdiagnose ein nur bedingt brauchbares Symptom, weil jeder Haematothorax zu einer basalen Pleuraschwarte führen kann, auch ohne dass eine Zwerchfellverletzung bestanden haben muss. Wertvoller ist der Nachweis einer umschriebenen, nicht randständigen Zwerchfellverschwielung; besonders dann, wenn er am diaphragmalen Herzbett gelingt. Wie wir sahen, ist eine frühe Reparationsphase der Zwerchfellverletzung durch eine umschriebene paraphrenische bzw. subphrenische Verklebung gekennzeichnet. Entsprechend umschriebene Verschwielungen des peritonealen und pleuralen Zwerchfellüberzugs sind als Folge zu erwarten. Sie können röntgenologisch als umschriebene Verdickung oder Beweglichkeitsminderung der zentralen Zwerchfellpartien erkannt werden. Die Diagnose einer früheren unkomplizierten Zwerchfellverletzung wird noch vollständiger, wenn eine Verschwielung des diaphragmalen Herzbettes an einer basal umschriebenen Pericardobliteration röntgenkymographisch ablesbar ist. Dass alle diese Symptome der Zwerchfellvernarbung nach Schussperforation im Röntgenbild erkannt und festgehalten werden können, zeigen folgende Beispiele von abgeheilten Zweihöhlenschüssen.

Fall 7. Fu. — Im ersten Weltkrieg »Brusts！teckschuss» mit Lungenverletzung re.; mehrfache rechtsseitige Pneumonieen in den folgenden Jahren. *Klinischer Befund:* Reizlose Einschussnarbe am re. Schulterblatt. Lunge: alte cirrhotische Spitzentbc. re. Herz: physikalisch o. B. EKG: Rechtstyp, Sinusbradycardie. Abdomen: o. B. — *Röntgenbefund:* ... zipfelige Ausziehung des re. Zwerchfells medial, laterale Zwerchfelladhaesionen bds. *Kymogramm* (senkrechtes Raster): Systolisches Aufwärtszucken des Zwerchfells li. medial. — Infanteriesteckgeschoss im li. Bauch, mehr dorsal.

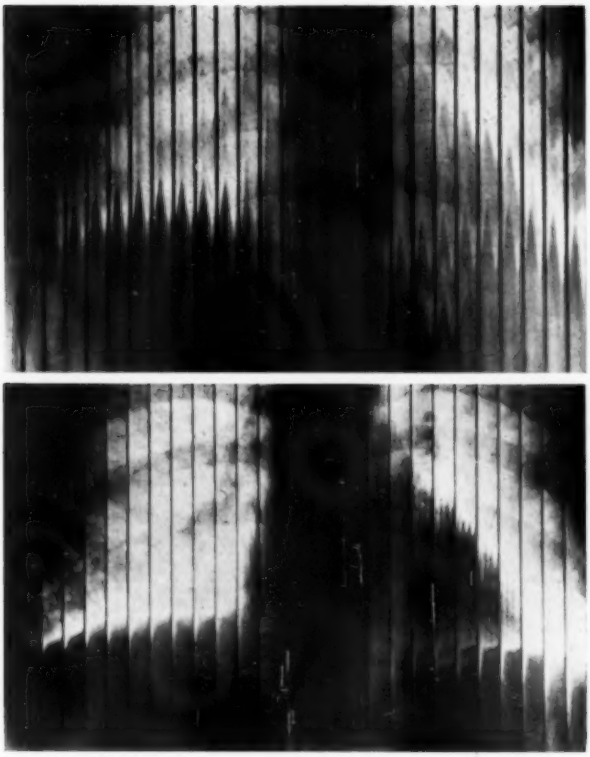

Abb. 8 a.

Abb. 8 b.

Abb. 8 a. Abgeheilte Zwerchfellschussverletzung bei Bauchschuss (nach 7 Jahren). Zwerchfelladhaesion rechts.

Abb. 8 b. Gleicher Fall. Medianer epiphrenischer Stecksplitter mit zentraler Zwerchfellvernarbung am Herzbett (accretio und concretio pericardii).

Das ein Zwerchfelldurchschuss vorgelegen hat, ergibt sich aus der abdominellen Lage des Geschosses bei Einschuss am rechten Schulterblatt; nach dem Schussverlauf ist die Perforation dorsal medial erfolgt. Als Restzustand der Lungen- bzw. Pleuraverletzung bestehen beidseitige Zwerchfelladhaesionen und eine mediale Ausziehung des rechten Zwerchfells. Im Spezialkymogramm (Abb. 7) wird eine Verschwielung des Herzbettes bzw. des Pericardialsackes am systolischen Zwerchfellzucken kenntlich (HAUBRICH u. THURN). Es beweist noch eindeutiger als die mediale Hochziehung des rechten Zwerchfelles, dass sich auf der Ober- und Unterseite der zentralen Zwerchfellabschnitte entzündliche Veränderungen abgespielt haben. Dabei soll dahingestellt bleiben, ob auch

eine Pericardverletzung vorgelegen hat oder die jetzige pericardiale Verschwielung der Restzustand einer Durchwanderungspericarditis infolge der reparativ-entzündlichen Vorgänge am Herzbett ist.

Einen umgekehrten Schussverlauf gibt der letzte Fall wieder. Hier handelt es sich um eine Granatsplitterverletzung aus dem letzten Weltkrieg; bei der Frühoperation wurde ein Bauchschuss mit Leberverletzung, Dünndarmdurchschuss und doppelseitigem Haematothorax festgestellt. Bei mehrfachen Einschussnarben am rechten Oberbauch (vorn und seitlich unter dem Rippenbogen) findet sich ein Stecksplitter dicht oberhalb des Zwerchfells (auf dem Bild bezeichnet), der sich rechts dorsal hinter der Herzbasis gut lokalisieren liess. Die Zwerchfellverletzung hat danach mehr zentral stattgefunden, eine Annahme, die sich wiederum röntgenkymographisch objektivieren lässt.

Das Atmungskymogramm (Abb. 8 a) zeigt eine adhaesive Bewegungseinschränkung des rechten Zwerchfells. Ausserdem deutet sich auch eine schwielige Zwerchfellverdickung links medial an, wo das Diaphragma gegen den helleren Herzschatten und die Magenblase sich beiderseits konturiert. Bei veränderter kymographischer Aufnahmetechnik (Atemstillstand und vertikale Schlitzstellung) wird erkennbar, dass dieser mediale Anteil des linken Zwerchfells systolisch nach oben zuckt, während der gesamte Zwerchfellrand beiderseits eine nur kleine pulsatorische Mitbewegung aufweist (Abb. 8 b). Wie wir an anderer Stelle gezeigt haben (Haubrich u. Thurn), lässt sich aus diesem Phänomen mit Sicherheit auf eine Verschwielung sowohl des Pericards (Concretio) wie auch der diaphragmalen Herzbasis (Accretio pericardii) schliessen. Im Zusammenhang mit den operativ festgestellten Verletzungsfolgen an Thorax und Abdomen kann hier angenommen werden, dass der doppelseitige Haematothorax nur sehr geringfügige pleurale Adhaesionen hinterlassen hat und dass der fast genau median epiphrenisch gelegene Stecksplitter zu einer recht umschriebenen Blutung, Verklebung und Verschwartung im Bereich des diaphragmalen Herzbettes geführt haben muss.

Es sei zum Abschluss darauf hingewiesen, dass diese Beispiele durchaus nicht selten sind. In dem reichhaltigen Begutachtungsmaterial dieser Nachkriegszeit haben wir eine grosse Anzahl solcher Fälle sammeln können, in denen die klinische Spätdiagnose einer Schussverletzung des Zwerchfells ihre objektive Bestätigung durch den Nachweis einer mehr oder weniger umschriebenen zentralen Zwerchfellverschwielung im Kymogramm gefunden hat. Es ist sicher, dass mit dieser Untersuchungstechnik viele Fälle noch nachträglich als Zwerchfellverletzungen bzw. Zweihöhlenschüsse erkannt werden können. Dies ist nicht überraschend, wenn man sich die klinische Symptomenarmut dieser Verletzung vor Augen hält.

ZUSAMMENFASSUNG

Die Frühdiagnose der unkomplizierten Zwerchfellschussverletzung ohne Intestinalprolaps ist klinisch nicht möglich. Röntgenologisch sind derartige Verletzungen jedoch sicher festzustellen, wie an einzelnen Beispielen gezeigt wird. Ein Pneumoperitoneum ohne Perforation eines gashaltigen Bauchorgans kommt dabei durch eine gleichzeitige Lungenverletzung zustande, auch ohne dass ein Pneumothorax noch nachweisbar zu sein braucht. Umgekehrt können subphrenische Gasansammlungen oft nur auf abdominelle Entzündungen zurückgeführt werden, obwohl gleichzeitig ein Pneumothorax besteht. Der Zwerchfellriss kann im Röntgenbild direkt sichtbar sein.

SUMMARY

Early diagnosis of uncomplicated bullet wounds of the diaphragm without prolapse of the intestine is not possible, clinically. Roentgenologically, however, the lesion is demonstrable. A few cases are reported which illustrate this fact. Also in cases without evidence of pneumothorax there may be pneumoperitoneum without perforation of a gas-containing abdominal organ in these cases if the lungs are also injured. On the other hand, subphrenic accumulation of gas may often be caused by inflammatory processes in the abdomen despite the fact that pneumothorax coexists.

RÉSUMÉ

Le diagnostic précoce des blessures simples du diaphragme par coup de feu, non accompagnées de prolapsus de l'intestin, est impossible par le seul examen clinique. Mais radiologiquement ces lésions peuvent être reconnues avec certitude, comme le montrent divers exemples qui sont rapportés. En pareil cas, et sans qu'il y ait perforation d'un viscère abdominal contenant des gaz, il se produit un pneumopéritoine dû à une lésion concomitante du poumon, et cela même sans qu'un pneumothorax soit encore nécessairement démontrable. Inversement, on peut souvent rapporter à des inflammations abdominales des collections gazeuses sous-phréniques en dépit de la coexistence d'un pneumothorax.

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A SIMPLE MASKING METHOD FOR THE LEVELLING OF CONTRAST IN RADIOGRAPHIC PRINTING[1]

by

Ove Mattsson

The making of good prints from radiographs is always a vital problem when illustrating radiographic reports and publications. The progress of the last few years in arteriography, aortography, soft tissue radiography, and so on is particularly exacting in this respect, as the radiographs produced show a very great amount of details, together with a very great density range.

The problem was recently presented by FRANTZELL (1950) who stimulated interest by demonstrating the very fine and interesting results of his method.

However, all methods described so far are fairly complicated and expensive, as admitted by the authors themselves. It has therefore been desirable to develop a cheap, simple, and rapid method of contrast levelling, requiring neither more equipment than that available in an ordinary photographic laboratory or radiographic department, nor any personnel with special training.

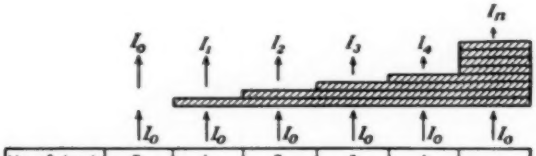
Before I enter into details about the method to be described here, I shall say a few words about the most successful attempts hitherto made to solve the problem. The difficulty is that of transferring the immense density range of the radiograph, a consequence of the two emulsion layers, to a photographic paper which covers only a relatively limited brightness range.

A picture on photographic printing paper is always viewed by reflected light. The difference in the amount of light reflected from the base of the paper and that reflected from the maximum black which the paper will produce constitutes the brightness range of the paper.

[1] Briefly presented at the meeting of the Swedish Association for Medical Radiology, Stockholm, June 3, 1950; submitted for publication, November 1, 1950.

In the case of films, it is the light transmitted which is of importance. HURTER and DRIFFIELD have expressed the relationships between the amount of silver produced by a given exposure under fixed conditions and its light-absorbing and transmitting properties. They defined as the *opacity* of the deposit (O) the ratio of the incident to the emerging light, as the *transmittance* (T) the reciprocal of this; and as *density* (D) the negative logarithm of the transparency. Thus, in a case of silver deposit transmitting $\frac{1}{10}$ of the incident light, the transparency is $\frac{1}{10}$, the opacity 10, and the density the common logarithm of this, or 1.0.

The definition has been given logarithmic form in accordance with Weber-Fechner's law, and its simple formulation has been possible through the application of Lambert's and Beer's laws. Lambert's law says that $I_x = I_0 \cdot 10^{-k \cdot x}$, I_0 and I_x being incident and transmitted light. k ist a constant, x is the thickness of the absorbing layer. If layers of the same thickness and absorbency are superimposed, the density values will thus be added. Let us suppose that two layers of the density (D) = 1 are superimposed; the total density will then be = 2 (the transparency will be $\frac{1}{10}$ and $\frac{1}{100}$ respectively). See fig. 1.



No. of sheets	0	1	2	3	4	n
Transmittance	1	$1/3$	$1/9$	$1/27$	$1/81$	$(1/3)^n$
Opacity	1	3	9	27	81	3^n
Density	0	0.477	0.954	1.431	1.908	$0.477n$

Fig. 1. Lambert's law of light absorption. (From J. E. Mack and M. J. Martin: The Photographic Process.)

The density range, *i. e.* the difference in transmitting densities between the most transparent and most dense parts, will be very great in the case of double layers, as used in radiographic film.

By also introducing, according to Beer's law the concentration (amount of silver per unit) of the absorbing substance (c), a general formula for the absorption of light is obtained in accordance with the law of Lambert-Beer: $I = I_0 \cdot 10^{-k \cdot x \cdot c}$. A doubling of the concentration of the light-absorbing substance will thus also double the density, the transparency being simultaneously changed, *e. g.* from $\frac{1}{10}$ to $\frac{1}{100}$. The eye's perception of the transparency wholly agrees with the logarithmic value of the density. Like other sensory organs, the eye reacts in accordance with Weber-Fechner's law, *i. e.* with a logarithmic evaluation of the impression made by the light.

In the case of *printing papers* it is the light reflexes of the silver deposit — *the reflection density* — which is of importance. The reflection density of papers, unlike the transmission density of films, is not directly proportional to the amount of silver per unit of area. It depends upon the surface reflection, the reflectance of the paper stock and the mass of silver, and may be expressed as $D_r = \log \frac{l}{R}$, where l is the intensity of the reflected light from the paper base free of an image, and R the intensity of light reflected from the deposit after a given exposure and development. — The difference in the amount of light reflected from the clear unexposed areas and that reflected from the deepest black constitutes the brightness range. Since $D_r = \log \frac{l}{R}$, the *density range* of the paper is the

logarithm of the brightness range. The maximum density of prints is limited by the amount of light reflected from the surface, and is seldom greater than 1.5 to 1.7, even on glossy papers. While the density range of papers is thus limited, that of usual films is greater, and usually exceeds 2. In Roentgen films, because of the double layers, it has extremely high values, up to 4, or more. The double layers produce the extreme contrast required for radiography, and also permit effective use of double intensifying screens.

The difficulty in printing radiographs is further accentuated by the fact that the density curve for printing paper is remarkably S-shaped, which causes a loss of contrast in the brightest and darkest parts of the prints, so that detail is lost more easily in those parts. A radiograph often contains details of diagnostic value in the dense and thin areas at the same time. Let us suppose that skeletal and soft parts are depicted in the same radiograph. A general reduction of contrast, compressing the various degrees of density within the brightness range of the paper, would then be of no value. Many valuable details are visible precisely because they stand out in contrast against their surroundings, and a general reduction of the latter would do away with many details which would then stand out too faintly to be observed. It would therefore be of the greatest value to obtain a general levelling of the exaggerated contrast between various areas, while keeping the differences in density between individual details. The areas in a radiograph which show extremely high or low density are usually contiguous — skeletal and soft parts for example — and contrast levelling would mean that both of these degrees of density in the film would be reproduced on the paper side by side, with a reduction of the great difference in density between various areas, but with the contrast between individual details within these areas retained. The object of contrast levelling, therefore, will be to create a varying degree of illumination of the radiograph in printing, controlled in such a manner that the densest[1] areas of the Roentgen negative are exposed to a maximum of illumination. ROBINSOHN, in 1930 described the good results that could be obtained by individual illumination control, using small lamps arranged in such a manner that the most heavily exposed parts of the image were most intensely illuminated. ROBINSOHN also used chemical treatment of radiographs and paper print, and in this way could locally improve the gradation of the image, with a resulting levelling of contrast. This method of illumination, in a modern and very versatile form, is practised by LINDBLOM, who uses an opal glass plate and, at a variable distance behind it, a large number of miniature lamps which are switched on individually by hand. The illumination may thus be modified in accordance with the radiograph, so that a suitable balance is obtained and the densest parts receive a

[1] Densest areas = areas with the highest exposure. Note that »dense» in this paper is used in the *photographical*, not the radiological sense.

sufficient amount of light. This arrangement produces very good results with radiographs of a simple contrast structure. The equipment, however, is fairly complicated and it is not always possible to produce the most favourable differences in illumination when areas of different density are too close to one another. LAURELL, according to FRANTZELL (1950), is reported to have attempted in 1929 before ROBINSOHN, the use of a transparency of the radiograph of appropriate density to control the illumination. This, of course, is a most ingenious principle, and the most correct method theoretically, for the transparency can be made to agree with photographic exactness with the radiograph's requirements of illumination in printing. It is used as a filter for selective control of the illumination; the densest areas of the radiograph will be most intensely and the most transparent areas the least intensely illuminated. The transparency was used in direct contact with the radiograph, and sufficient adjustment of the illumination for making balanced prints was obtained. Unfortunately, however, the method only reduced the gradient of the density curve, or in other words, the general contrast, and, as I have pointed out before, this fact was also bound to influence the rendering of detail unfavourably. Further, it was difficult to secure perfect register, so that the images covered each other; double contours were frequent. Immediately afterwards SPIEGLER and JURIS (1930) described a method for employing transparencies; but they deliberately used a diffused, unsharp transparency which was produced by printing in diffuse light, with a space between radiograph and transparency. This diffused transparency, when used, wholly lacked the details of the radiograph, though it showed average densities corresponding to the different areas. This permitted a control of illumination as a whole without influencing individual fine details, the visibility of which was preserved. SPIEGLER and JURIS also indicated the possibility of using paper, but the papers available at that time were so far from being transparent that they had to be greased after drying to produce the desired effect. This proceeding was an awkward one, and plates or film were therefore used instead. During the printing the diffused transparency was placed in contact with the radiograph. Good results were obtained in this way.

Similar methods using transparencies as masking filters have been practised in technical photography. Kodak, for example, has outlined a similar proceeding for the printing of line negatives, such as maps or engineering drawings. A diffused transparency is used to control the illumination in order to prevent adjacent lines from merging, or isolated fine lines from disappearing. The method is called the Kodak Fine Line Process. For colour-correction in connection with photo-engraving and lithography masking methods have been used for a long time to correct the faulty spectral sensitivity in the negative materials or filters. Without

masking it is impossible to obtain perfect colour rendering in a subtractive process. The masking improves the relationship between the colour densities and gives thus better results. The first suggestions appear to have come from E. ALBERT of Munich, who, in 1897, combined a masking positive with the colour separation negatives.[1] A number of different methods have been suggested after that and especially Eastman Kodak Laboratories have worked out various modern methods. The Kodak Magenta Method of Colour Reproduction is one of those. At first the masking transparencies were made sharp, but soon it was discovered that a small diffusion was favourable.

An extremely important advancement, not least from the financial standpoint was the use of small transparencies reduced photographically, which, when projected[2] in identical position and enlarged to the size of the film, could be used as a substitute for a transparency of the size of the radiograph. FRANTZELL, using equipment of his own design, has produced excellent results with this method. He used miniature negatives, but has lately employed a size of 6 × 9 cm on 9 × 12 cm plates. The cost of the transparency was considerably reduced, compared to the cost of large transparencies of the size of the radiograph. The method, however, requires an instrument of special design, a combined camera and enlarger, complete with illumination system, as well as extreme precision in manipulation.

In ordinary photography, various methods have long been used for the levelling of contrast when printing negatives with a wealth of contrast. Ever since two negatives — one for the highlights and another for the shadow areas — were first used according to the Person process (so that the tones were *separated* and the two negatives were then used for printing), the term tone separation has been used. This expression, however, should be reserved for similar processes in ordinary photography and is, as a matter of fact, not suited for the proceedings described above; *contrast levelling* is probably the most adequate expression. Of course, some of the contrast levelling methods used in ordinary photography may be used, but they are either too time-consuming, not easily applied to radiographs of normal size or will give an inferior rendering of detail in the areas concerned.

I present here a brief description of a method reported by URBACH and SONN (1940), together with a proceeding described by EMMERMANN (1937) and first outlined by MENTE (1912). These are not generally known, but nevertheless interesting.

[1] German Patent (D. R. P.) 101379 ($^{16}/_{9}$ 1897) Dr. E. ALBERT.

[2] A masking method using *projection* was introduced in England by a New Zealander, E. H. GAMBLE, in 1912. That was an early method for colour-correction in colour-photogravure, in which differential lighting of the original was secured by projecting a positive image upon it during the making of a negative. (British Patent 6768, $^{19}/_{3}$ 1912, E. H. GAMBLE.)

The first method is based on the Herschel effect, *i. e.* the capacity of longwave light to extinguish a latent image produced by other light. An ordinary exposure for printing is first made, and controlled in such a manner that the areas situated under the densest parts of the film also receive a sufficient amount of light. The other parts of the paper will of course be too heavily exposed. The normal source of light is then replaced by a red light of high intensity which, when the time of exposure is sufficient, reduces the effect of the first exposure. The parts of the paper containing the heaviest over-exposure and situated under the thinnest parts of the film are influenced most strongly, and a contrast-levelling effect is produced. If the film is separated from the paper by a few millimetres during the second exposure, the result will be an over-all levelling with better preservation of local details. Practical tests made by the author with this method showed that it was both slow and difficult, because of the large size and frequent high density of radiographs.

The contrast levelling method most employed in enlarging work, involving the use of a two-step exposure on paper soaked with developer, was described by BÄCKSTRÖM and HAFSTRÖM (1939) after EMMERMANN (1937). The first exposure is adjusted so as to give an image on the paper corresponding to the thinner areas of the film. During the second exposure this image protects the thinner areas against excessive illumination and the result is a print showing levelled contrast. A sensitometric examination made by BÄCKSTRÖM and HAFSTRÖM showed that the density curve is deformed in its upper part in such a manner that the rendering of detail, which is of extreme importance in radiographic work, is threatened in areas with certain degrees of density. Even reversed rendering may occur, as the density curve shows a downward bend, a phenomenon which most of all resembles a localised Sabattier effect. The danger of fogging through atmospheric action exists while handling paper soaked with developer, although this danger may be reduced somewhat by the use of preventive agents (Bellatone C and others) containing nitrobenzimidazol.

The method I am going to describe requires no complicated equipment and though simple and rapid, produces good results. In accordance with previous methods, a photographic image is used as a filter mask for controlling the illumination in printing. A print on document paper, which is extremely thin and transparent, is used; its transparency is improved by the fact that it is not dried before being used as a mask.

Document papers have a very thin and light paper base (according to the manufacturers about 85 g per square meter for the paper used in this case). Normal printing papers weigh about twice as much, or more.

Document papers are usually of the high contrast type, which has proved very suitable. Moreover, they are the cheapest existing photographic material and priced at about 40 % of ordinary printing paper. All sizes up to the standard size A 3 (about 30 × 40 cm) are available.

A contact print is first made on this paper, which is to be used as a

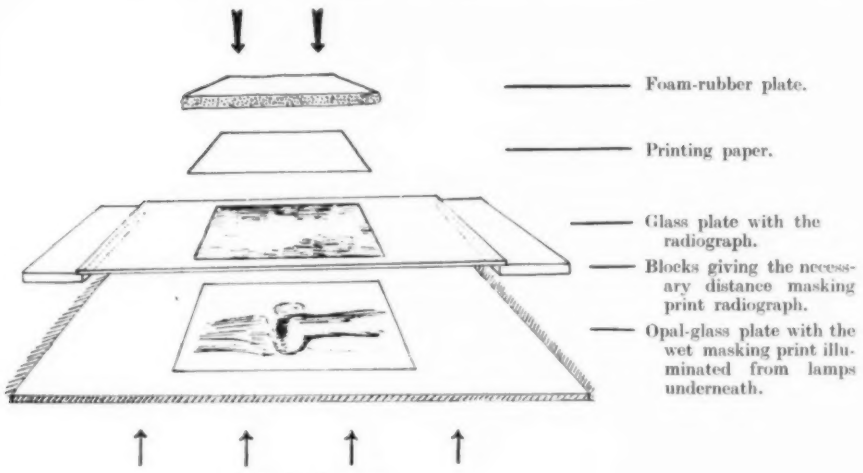

Foam-rubber plate.
Printing paper.
Glass plate with the radiograph.
Blocks giving the necessary distance masking print radiograph.
Opal-glass plate with the wet masking print illuminated from lamps underneath.

Fig. 2. Lamps.

mask. The only equipment necessary is a viewing table which produces a uniform diffused illumination. It should be designed like a roentgen film viewer, but with a horizontal viewing glass. An opal glass plate with a few electric lamps underneath — a piece of equipment commonly used in photographic laboratories for the inspection of negatives — is quite sufficient. After the exposure, which is very short because of the high sensitivity of the paper (usually a couple of seconds), the print is developed in an ordinary paper developer. The development should be carried far enough, so that the picture is completely developed, for the sensitive layer is to transmit the light and should therefore have good density in the blackest parts. One or two minutes will be quite sufficient time for development. After a minute in the fixing bath and a quick washing the masking print is ready for use.

Document papers are fixed very quickly; 3 minutes will be sufficient, according to the manufacturers. One minute is enough if the filter print is not to be kept for future use.

The wet paper print is rolled out flat on the opal glass plate. Another glass plate is placed on top of it, and the radiograph is laid on this plate and moved into register while the illumination is on. The required diffusion is obtained by separating radiograph and filter mask from each other, the glass plate being raised by inserting spacing blocks of varying heights: The differences between radiograph and mask have been 7, 11, or 14 mm. Last of all, the final printing paper is placed on top of the radiograph in darkroom light and pressed absolutely flat by a weighted foam-rubber

Fig. 3. This arrangement was used in printing all the radiographs reproduced in this article. The illuminated opal glass plate is that of a negative viewer; the translucent wet masking print has been rolled out flat on this plate. The arteriography being printed is the one shown in fig. 12. On the spacing blocks is a clear glass plate on which the radiograph is moved into register. The register is checked by the eye.

plate. The latter arrangement has proved indispensable for the purpose, as it permits a perfectly uniform distribution of pressure. Before I introduced it, local lack of sharpness was often observed. After one or two test exposures on strips of paper to obtain the time of exposure and the appropriate degree of diffusion, the final exposure can usually be made on a large paper. A restrictive exposure followed by complete development is recommended. Fig. 2 illustrates the printing procedure. The wet masking print is rolled out flat on the opal glass plate; above it is the glass plate with the radiograph in register, and on top is the printing paper and the foam-rubber plate. Fig. 3 illustrates one of the operations: the radiographic film is applied and moved into register. Fig. 4 shows how the foam-rubber plate is applied without displacing the other elements of the assembly below it.

Fig. 4. The final printing paper is placed on the radiograph (in darkroom light) and a foam-rubber plate is applied without displacing the elements of the assembly below it.

A difficulty which soon presented itself was the stretching of photographic paper when soaked. If a paper is to be used as a filter for controlling the illumination, it must retain the same size as the radiograph all through the processing.

KRETZ (1939) maintains that stretching in processing up to 2.5 to 3 % is usual for ordinary papers. BRUNO (1942) reports values of 1 to 2 %, with variations according to fibre direction. The observations of these authors agree well with the results below. The stretch is conserved by drying the print on a glazing plate; free drying, on the other hand, makes it revert to its original size, and a slight shrinkage results instead. EDER reports values of 0.3 to 0.5 %.

To eliminate the effect of dimensional change in processing, I studied it more closely. The investigation included various types of document papers, as well as different fibre directions.

The paper increased in size and the maximal stretch varied along with the type of paper and the fibre directions. Values between $^2/_3$ % and 3 % were observed; a frequent figure was about 2 %. Fig. 5 shows a curve representing the paper and the fibre direction which gave maximum stretch. The graph can be regarded as representative of the process of dimensional change for the times of processing concerned. It was found that the effects of stretching are easily compensated by wetting

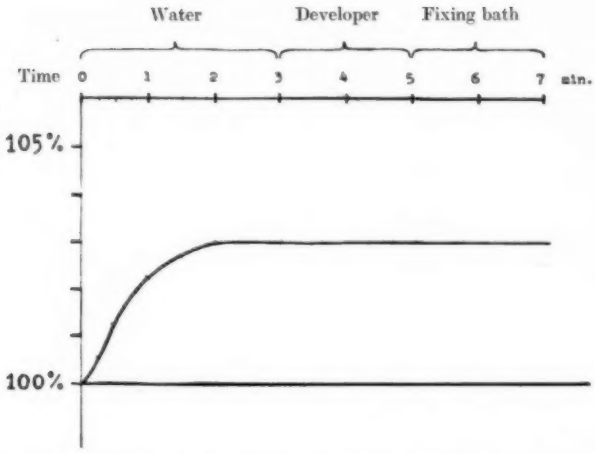


Fig. 5. Dimensional change of a document paper in water — developer — fixing bath. Original length of paper = 100 %. (Gevaert Document Rapid in the direction showing maximum stretch.)

the paper before processing. As indicated by the graph, a maximum size is rapidly reached which is retained all through the processing. The document paper should therefore be soaked in water in darkness, so as to reach its final dimensions before it is exposed in a wet condition. The separate tank used for soaking the paper must be absoutely clean, and soaking in a tank used for rinsing prints previously fixed is absolutely forbidden, even though running water be used. The presence of hypo, however small the quantity may be, will destroy the paper immediately. The wet paper causes no difficulty in printing, as it is separated from the dry roentgen film by a clear celluloid film of adequate size.

Now a few words about the choice of paper. Paper used for the masking print should be selected in accordance with the character of the radiograph. A radiograph showing extreme contrast and requiring a large amount of levelling requires a paper of the hardest type, such as »contact» paper. For other purposes softer paper, sometimes called »rapid» paper, is most convenient. Double papers can also be used. The logarithmic doubling of the density produces an extension of the density range, and consequently a considerable increase of the contrast levelling. Naturally, diffusion and the influence of the two paper bases reduce the effect a good deal, but double papers will give good results in more difficult cases.

The use of thin and transparent papers seems to be the most correct

Fig. 6. Normal soft tissues of a knee. (A boy aged 15.)

Fig. 7. The other knee of the same patient. After an injury there is an oedema around the patellar ligament and a small fracture on the tuberosity of the tibia.

Fig. 8. Normal patellar ligament.

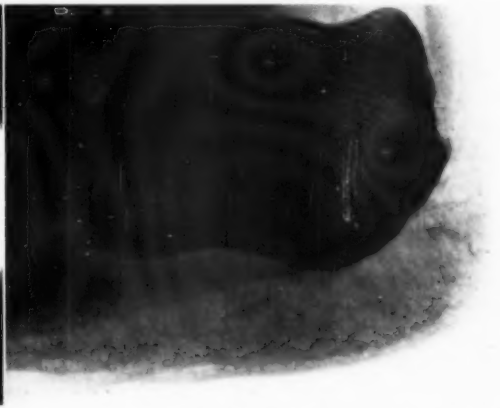


Fig. 9. Normal soft tissues of a heel. Notice the Achilles tendon. A small spur at the insertion of that tendon.

Fig. 10. Lateral view of the hypopharyngeal region. Calcifications in larynx.

Fig. 11. Cholangiography.

way of producing a levelling of contrast by control of the illumination through selectively filtering photographic emulsions. There are, no doubt, types of paper thinner and more transparent than those used here — such as those used as negatives for document filing, map reproduction and air-mail letters which weigh down to 40 g per square metre (Airmail Bromide) or a special translucent double emulsion-coated paper of very thin texture, known in U. S. A. as Translite — but these types are usually extremely contrasty and particularly high-sensitive and orthochromatic, and therefore more difficult to handle than low-sensitive papers. They are also more expensive. The document papers used here, designed for contact printing and projection photocopying, seem to represent the type which is most suitable from all points of view.

The difference between the amount of light transmitted by the paper base only and that transmitted by the blackest parts of the document paper represents its suitability for contrast levelling purposes. A densitometrical measurement of the sort of document paper used by the author gives the density values 1.0 resp. 2.2 for the base only and the maximum black parts in wet condition. The difference in densities is thus 1.2. As the antilogarithm of 1.2 is about 16, that means that the illumination of the radiographs being printed varies because of the

Fig. 12. View of the flank of a patient with carcinosis peritonei and ileus. Fluid in the peritoneal cavity. Notice the three muscle layers of the abdominal wall.

masking print so that the most dense parts if necessary will receive about *16 times* more light than the least dense.

As for the printing paper, soft and normal contrast grades will be required in the first place. Hard grades may be required occasionally. On the whole, contrast levelling permits the use of harder paper than direct printing, and the consequent gain will be increased detail contrast. Roentgen paper, sometimes used instead of film, is extremely soft-working and may be used for very hard radiographs.

Arteriographies

Fig. 13. Arteriovenous aneurysm.

Fig. 14. Malignant tumor in the femoral region.

Fig. 15. Phlebography.

Fig. 16. Aortography.

The time required to make the prints is not particularly long. Including test exposures, the making of the wet masking print rarely requires more than 7 to 10 minutes, and the subsequent printing is done with approximately the same speed as ordinary printing without contrast levelling arrangements. All regular sizes up to 30 × 40 cm can be processed without difficulty.

Diffusion constitutes a special problem. As a rule, the masking print was made sharp, and diffusion of the illumination was created by a suitable distance between print and film. In certain cases, when the radiograph showed particularly fine detail, a certain diffusion was instead created by a slightly unsharp filter print, produced by the absence of

Fig. 17. Arteriography.

flattening during the exposure — in combination with a proportionally shorter distance between filter and film. As stressed by LINDBLOM, the relief phenomena which often appear in these types of levelling methods are a great disadvantage. By varying the distance and, as mentioned, also the sharpness, it has been possible to adjust the diffusion in such a manner that the danger of contour phenomena was avoided as far as possible. The effect of the levelling is judged immediately by replacing the paper with a ground-glass plate.

The method has not been tried on any great number of radiographs as yet, but when used it has produced good results quickly and easily. Figs. 6—18 show some examples from different fields. They are taken

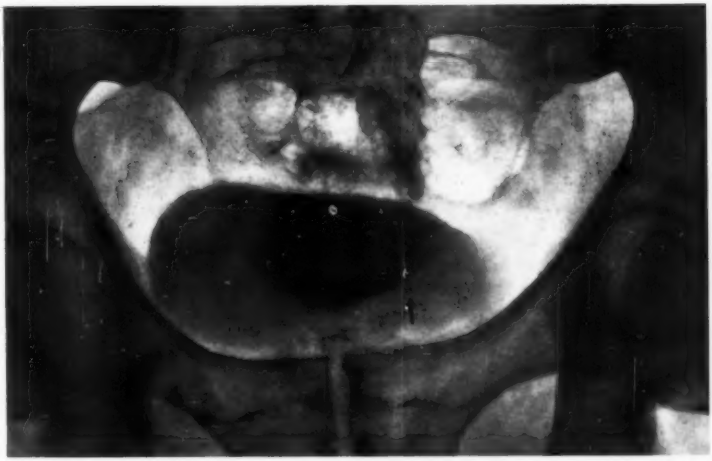


Fig. 18. A urinary bladder filled with contrast (a ureteral calculus marked by arrow).

Fig. 19. An ordinary print.

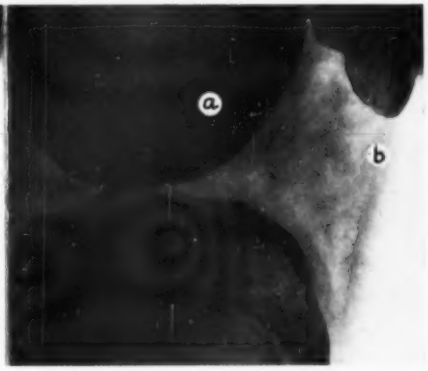


Fig. 20. A contrast-levelled print.

principally from radiographic fields in which contrast is a vital problem, such as angiography and soft-tissue radiography. Some illustrations derived from other fields show the effect of levelling with respect to skeletal and soft parts in abdominal and pelvic radiography. I should like to point to Fig. 6 or 7 as examples of surprisingly fine contrast levelling. On direct inspection, the radiograph here shows densities varying between the practically transparent skeletal parts and the very compact dense areas in the soft parts. The levelling of contrast has

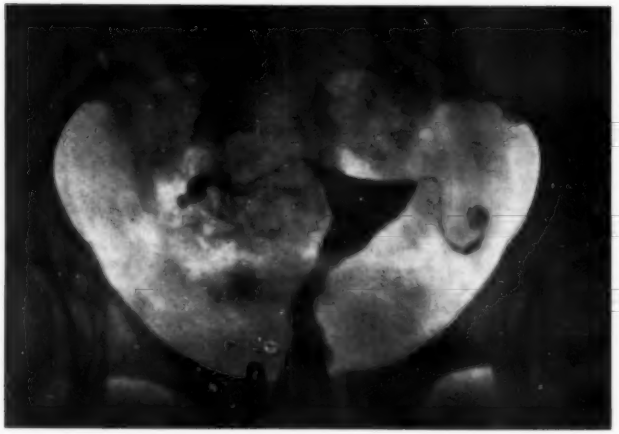


Fig. 21. Hysterosalpingography.

Fig. 22. Negative copy of fig. 21.

brought these two densities together on the print in a manner agreeable to the eye and well suited for photo-engraving, and they do not differ very much from each other. The transition between the two levelled density areas is imperceptible, without double contours or disturbing relief phenomena.

The difference between an ordinary print and a print made with contrast levelling is demonstrated in Fig. 19 and Fig. 20. In this case the densitometer registered densities of $D = 0.4$ and $D = 2.0$ on the spots a and b of the radiograph. A number of Å. LINDBOM's illustrations in his chapter on »Angiographie» in SCHINZ, Lehrbuch der Röntgendiagnostik (5th ed.), were made with the author's method.

If a *negative* print of the levelled radiograph is desired, it is easy to photograph the positive print in a reproduction camera of the type usually available in the photographic departments of large hospitals, on a paper of desired size or a lantern plate. It is not difficult to keep a suitable gradation if the hardness of paper or plate is correctly chosen. Fig. 22 was reproduced in this manner from the contrast-levelled print in Fig. 21.

The manufacturers of photographic materials declare that the use of positive-developing papers will be a reality in the near future. These papers work according to the solarisation principle; if unexposed, the paper shows maximum density when developed, and the density is further inversely proportional to the lighting, so that light of higher intensity produces the highlights of the picture. With these papers, printing will give direct positive pictures.

A negative print of a small detail can also quite well be made via a photographic plate or film, which replaces the printing paper and which can then be printed in the normal manner. Roentgen film, with its two emulsions, cannot be used for this purpose, because halation will destroy the rendering of detail. The best way is to use an ordinary anti-halo plate or film. The print is given its required size in the enlarger.

To obtain a contrast levelling already in the radiograph, the author has tried to use »depth development», a separated development in two baths. This proceeding, which gives a blackening through the whole depth of the emulsion layer in a more adequate manner than ordinary development, also limits the blackening of the more dense parts. A general report on my experience of this proceeding will be published in a future paper.

SUMMARY

The author describes a method for contrast levelling in printing roentgen film which is simple, rapid and cheap compared with previously described methods.

A very thin photographic paper of document type is used for the contrast levelling work. A wet print of the radiograph on this paper is used as a filter for illumination control during the printing which is made on ordinary paper. A certain variable distance between the filter print and the film produces sufficient diffusion for the elimination of disturbing contour phenomena, and also produces adequate detail contrast.

ZUSAMMENFASSUNG

Verfasser beschreibt ein Verfahren zum Kontrastausgleich beim Kopieren von Röntgenbildern, das zum Unterschied gegenüber früher beschriebenen Methoden einfach, schnell und billig ist.

Ein sehr dünnes Fotopapier, sog. Dokumenten-Typ, wird zum Kontrastausgleich verwendet. Eine Kopie des Röntgenbildes darauf dient in feuchtem Zustand als ein helligkeitsausgleichendes Filter während des Kopierens, das auf gewöhnlichem Kopier-

papier vorgenommen wird. Ein gewisser veränderlicher Abstand zwischen der Filterkopie und dem Film ergibt die gewünschte Diffusion zur Vermeidung von störenden Umriss-Verzeichnungen und zugleich den besten Kontrast zwischen den Einzelheiten.

RÉSUMÉ

L'auteur décrit un procédé pour attenuer les contrastes dans la copie des radiographies. Ce procédé est simple, rapide et bon marché contrairement à ceux précédemment connus.

On utilise un papier photographique très mince du type dit »document». Une copie humide de la radiographie en question, sur ce papier, sert de filtre pour la lumière, lors de la copie définitive, qui est faite sur papier-copie ordinaire. Une certaine distance variable entre la copie-filtre et la pellicule donne la diffusion nécessaire, pour éviter les phénomènes gênants dans les contours, et aussi le meilleur contraste dans les détails.

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CHOLECYSTITIS EMPHYSEMATOSA[1]

by

Carl F. Qvist

Cholecystitis emphysematosa (c. e.) is a gall-bladder infection accompanied by formation and accumulation of gas in the gall-bladder and sometimes also in the biliary tract. It is a rare lesion, the world's literature apparently containing only 24 thoroughly examined cases, none of them from Scandinavia. Before reporting a case seen recently at the Aalborg Municipal Hospital, the writer will give a brief review of previous cases, touch upon the pathological anatomy, bacteriology, and treatment, and describe the roentgen findings in more detail.

STOLZ, in 1901, was the first to describe gas in the gall-bladder, found post-mortem in three cases. It is doubtful, whether these cases are interpretable as true c. e.

In 1908, LOBINGIER reported a case in which operation revealed gas in the gall-bladder and gangrene of the mucous membrane. After cholecystectomy the patient recovered.

TANNER, in 1921, and KIRCHMAYR, in 1925, reported one case each in which operation revealed acute phlegmonous cholecystitis with accumulations of gas.

HEGNER (1931) was the first to make a preoperative diagnosis (by roentgen-ray). The patient was a male, aged 62, presenting symptoms of acute cholecystitis. A plain film of the gall-bladder region showed a pear-shaped gas shadow corresponding in size and shape to an enlarged gall-bladder. In the course of a few days, the gas shadow increased, and small gas bubbles were seen in the pericholecystic tissue. Operation showed emphysema of the gall-bladder wall and air under pressure in the acutely inflamed gall-bladder. A drain was inserted into the gall-bladder, but the patient expired 4 days later from pulmonary embolism.

[1] Submitted for publication, Oct. 24, 1950.

Author (year)	Sex Age	Diabetes	Calculi (number)	Operation (procedure)	Bacteria found at operation	Result
Lobingier 1908 ...	♂ 55	÷	One	Cholecystectomy	(? prep. destroyed)	Cured
Tanner 1921	♂ 44	?	÷	Cholecystectomy	Str. and coli	Cured
Kirchmayer 1925 .	♂ 64	?	Several	Cholecystectomy	Cl. Welchii	Cured
Hegner 1931	♂ 62	?	One	Cholecystostomy	»Atypical Cl. Welchii»	Died on 4th postop. day
Simon 1932	♂ 32	?	Several	Cholecystectomy	»Anaerobic spores»	Cured
Wybauw 1936	♀ 53	?	Several	Cholecystectomy	Not exam.	Cured
Schmidt 1938	♂ 38	?		No operation		Cured
Del Campo & Otero 1940.....	♂ 74	?	Several	Cholecystostomy	Cl. perfringens	Died on 4th postop. day
McCorcle & Fong 1942	♂ 49	+	÷	Cholecystostomy	Cl. Welchii + coli.	Died (retrospective finding)
McCorcle & Fong 1942	♂ 59	?		No operation		Cured
McCorcle & Fong 1942	♂ 49	+		No operation		Cured
Stevenson 1944...	♂ 64	+	Several	Cholecystostomy	Aerobic & anaerobic str.	Cured
» » ...	♂ 63	?	One	Cholecystectomy	No growth, no anaerobic test	Cured
» » ...	♂ 52	?		No operation		Cured
Hutchinson 1946 .	♂ 56	?	Several	Cholecystectomy	Cl. Welchii	Cured
Culver & Cline 1948	♂ 60	+		No operation		Cured
Heifert & Senturia, 1948	♂ 52	÷	Several	Cholecystostomy	1. str. faecalis 2. paracolon bacillus 3. anaerobic rods	Cured
Heifert & Senturia, 1948	♀ 57	÷	Several	Cholecystectomy	Cl. filiformes	Cured
Jemerin 1949	♀ 68	+	Several	Cholecystectomy	Cl. oedematiens	Died 24 hours after operation
Aurelius, Friedman & Rigler 1949	♀ 53	÷	One	Cholecystectomy	Str., no culture	Cured
Aurelius, Friedman & Rigler 1949	♂ 68	÷		No operation		Cured
Aurelius, Friedman & Rigler 1949	♂ 66	+		No operation		Cured
Aurelius, Friedman & Rigler 1949	♀ 64	+		No operation		Cured
Elsey & Hudson 1950	♂ 75	?	÷	Cholecystostomy	Cl. Welchii	Cured
Qvist 1950	♂ 63	÷	One	Cholecystostomy	No growth	Cured

Operation had not shown any calculi, but autopsy revealed one stone in the gall-bladder. The pus proved to contain »atypical Cl. Welchii».

One year later, a similar case was reported by Simon. The patient, a 32-year-old male, exhibited symptoms of acute cholecystitis. Roentgen

showed a fluid level at the site of the gall-bladder and infiltration of gas in its wall. Operation (cholecystectomy) showed a gangrenous gall-bladder containing several small stones. Direct smears of the pus showed »anaerobic spores». No culture was made. The patient recovered.

In 1936, WYBAUW reported a case occurring in a female, aged 53, who recovered after cholecystectomy.

In 1938, SCHMIDT reported a case in which recovery followed upon conservative treatment.

Recently, several new cases have been reported, mostly by American workers.

In the literature the writer has found a total of 24 cases in which adequate clinical data are available. These cases are set out in tabular form together with the present case.

The patients range in age from 32 to 75 years, the majority being in the 7th or 8th decade of life. Twenty were males and only five females.

With regard to the bacteriology, various bacteria have been held responsible. This must be due largely to the varied nomenclature used for anaerobic bacteria. Most of the cases appear to have been caused by anaerobic bacteria of the Welch group, but other bacteria have been found as well, particularly coli (cf. the table).

GORDON-TAYLOR and WHITBY have reported growth of Cl. Welchii in 18 % of 50 gall-bladders removed surgically and in 13 % of a post-mortem series. It has been shown experimentally by THORNESS that these strains are non-sporulating and of low virulence.

In all but 3 of the operated cases, stones were present in the gall-bladder. The reports do not state whether probes were passed through the common duct in cases where no stones were found.

It is interesting to note that 7 out of the 25 patients were diabetics. The explanation is probably that gangrene is more apt to develop in diabetic than normal subjects.

Clinically, it is impossible to distinguish c. e. from acute cholecystitis unaccompanied by gas-formation.

The pathological findings are enlargement of the gall-bladder which is tense and shows a thickened wall. The latter is crepitant and fixed to the neighbouring organs by numerous adhesions. Often, the mucosa is gangrenous and completely separated from the muscularis.

Opinions are divided as to the *treatment*. HEIFERT and SENTURIA recommend operation (cholecystectomy) in the first stage of the infection, since the risk of perforation is said to be greater than in ordinary acute cholecystitis because of the widespread gangrene of the wall. JEMERIN also prefers operation, either in the acute phase or in a symptom-free interval, whereas others (*e. g.* MCCORCLE and FONG, AURELIUS and co-workers) recommend conservative treatment. The latter has comprised

measures ranging from merely bed-rest to application of gas gangrene serum, antibiotics, and in one case even roentgen irradiation.

Among the 24 cases, 17 underwent operation and of them 4 died. All the conservatively treated patients recovered.

Roentgen Findings. As a rule, no gas is visible in the first 24 to 48 hours after the onset of the disease. At the end of this period, however, a gas shadow appears at the site of the usually enlarged gall-bladder, surrounded by a darker, concentric annular shadow (gas in the wall of the gall-bladder). If the film is made in the erect posture, a horizontal fluid level may be seen. In the course of a few days the annular shadow becomes vacuolized and striped, showing gas bubbles in the surrounding tissues as evidence of pericholecystitis. The biliary tract may be distended with gas, but this is not usually the case. If the patient does recover without operation, the gas gradually subsides, but even after a clinical cure has been obtained, small amounts of gas may persist. McCorcle and Fong have published two excellent series of roentgenograms for 2 non-operated patients, illustrating the course outlined above.

A differential diagnostic possibility is that the gas might have reached the gall-bladder through a fistula from the intestinal tract or through an incompetent sphincter of Oddi. In that case, the gall-bladder is usually of normal size and roentgen shows neither an annular shadow nor gas bubbles in the pericholecystic tissue. The roentgen-ray appearances of c. e. are thus, very typical, practically speaking pathognomonic. A diagnosis can be made in nearly all cases on the basis of the roentgen-ray signs and clinical findings. In cases of doubt, it is worth trying to exclude the presence of a fistula by administering a barium meal or enema.

In lipomatosis of the gall-bladder there may also be an annular shadow, but in that case gas is absent.

Writer's Case

A male, aged 63, admitted to the surgical department from Feb. 17 to Apr. 8, 1950 (Case rec. 741/50).

Past history on the whole negative except for some uncharacteristic dyspepsia for years. Six days prior to admission he had pains like those for which he was admitted, but they had subsided spontaneously in the course of a few hours.

About 24 hours before admission he developed constant pain below the right costal border, radiating slightly to the back. He had vomited several times, and had been at stool a few hours before admission. Had not noticed the colour of the fæces. Since then, no passage of flatus. Urination normal, but the urine had been rather dark in the morning.

Obj. exam. showed a non-debilitated patient, temperature 38.8° C., pulse rate 96. No jaundice. Abdomen soft, marked tenderness at the site of the gall-bladder, less marked in the epigastrium and at Mc Burney's point. No abnormal dullness or swelling. No other abnormal objective findings.

Fig. 1.

Laboratory tests: Urine pale, clear, no albumin, sugar, or pus; micr. exam.: Nothing abnormal. S. R. 38 mm., Hb. 93 %, icterus index (Meulengracht) 9, diastase figure 150. The fever and pain subsided in the course of a few days.

Roentgen findings: A plain film of the gall-bladder region (Fig. 1) shows a cavity filled with gas below the liver. The cavity, which is as large as a hen's egg, shows a fluid level and is connected superiorly with a number of irregular accumulations of gas, forming together a system of canals between the 12th rib and the vertebral column. Since the appearances suggested an air-filled gall-bladder, it was presumed that he must have a fistula to the gastro-intestinal tract. Films made after administration of a barium meal, however, did not show any communication between the gall-bladder and the intestinal tract, not even at the end of 24 hours. A fistula was not either demonstrable after a barium enema. On the last-mentioned films the gas shadow was unchanged.

Cholecystostomy was performed on March 9 under nitrous-oxide-oxygen-ether anæsthesia. The gall-bladder adhered firmly to the under surface of the liver as well as to the colon and omentum. It was found to contain a good deal of pus which was removed by suction after inoculation for culture. No growth was obtained (regrettably, it proved impossible to find out, whether only aerobic technique had been used). The gall-bladder mucosa was gangrenous and completely separated from the wall. After its removal histological examination showed a highly necrotic, granular, filamentous tissue specimen in which any gall-bladder structure was obliterated. In addition, a few particles of young granulation tissue with moderate round-cell infiltration.

A calculus, as large as a pea, could be palpated in the gall-bladder. When it was to be removed, it slipped into the cystic duct which was as thick as a little finger. A drain was inserted into the gall-bladder.

The postoperative course was uneventful.

Cholangiography 9 days after the operation showed a dilated cystic duct with a filling defect as large as a pea, suggesting a concretion. Ether was injected through the drainage tube by the method of Pribram, but cholangiography 10 days later showed the filling defect unchanged.

On Apr. 4, the drain was removed during suction. No stone was recovered. On Apr. 8 the patient was discharged in good health. The wound had healed except for a very slight secretion from the site of the drain.

At a follow-up examination on May 25, 1950 the patient stated that he had been feeling well after the operation. Hb. 95 %, S. R. 26 mm. There was, however, still a slight secretion from the site of the drain. (On Sept. 6, 1950 the fistula had healed.)

A plain film of the gall-bladder region in May showed some opaque medium at the site of the gall-bladder and of the fistula from the gall-bladder to the exterior. No sign of concretion.

Cholecystography did not show the shadow of the gall-bladder.

As also mentioned by a few previous authors, the incidence of c. e. is probably not as low as the small number of reported cases would lead one to believe. If plain films of the gall-bladder region were made in all cases presenting symptoms of acute cholecystitis, the disease would probably be detected in no inconsiderable number of cases. A positive finding would also be of the utmost differential-diagnostic importance in obscure cases of acute abdominal conditions.

SUMMARY

Cholecystitis emphysematosa has been but seldom reported. After reviewing 24 cases found in the literature, the writer deals with the roentgen findings in detail and adds a case of his own. It is suggested that roentgen examination be used more extensively in cases presenting symptoms of acute cholecystitis and in obscure abdominal conditions.

ZUSAMMENFASSUNG

Über Cholecystitis emphysematosa ist nur selten berichtet worden. Nach der Besprechung von 24 Fällen, die sich in der Literatur fanden, behandelt der Verfasser die Röntgenergebnisse im Einzelnen und fügt einen eigenen Fall hinzu. Es wird vorgeschlagen, die Röntgenuntersuchung in grösserem Umfange in Fällen mit Symptomen von akuter Cholecystitis und weiter bei unklarer Bauch-Situation anzuwenden.

RÉSUMÉ

La cholécystite emphysémateuse n'a été l'objet que de rares publications. Après une revue de 24 cas trouvés dans la littérature l'auteur traite, en détail, des constatations radiologiques, et ajoute un cas personnel. Il suggère le recours plus fréquent à l'examen aux rayons roentgen chez les malades présentant les symptômes d'une cholécystite aiguë, de même que chez ceux qui sont atteints de troubles mal définis du côté de l'abdomen.

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ROENTGEN TREATMENT OF CANCER OF THE OESOPHAGUS[1]

by

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Introduction

The treatment of cancer oesophagi gives extremely poor results compared with other carcinomas. Several factors play a part in this respect, particularly the difficulty in diagnosing the condition at an early stage. The symptoms are rather vague and neither the patient nor the physician first consulted seem to pay proper attention to them, and valuable time is consequently lost.

Owing to its position, both surgical and radiological treatment of the oesophagus is intricate, and surrounding vital organs are easily injured. Furthermore, the oesophagus is a canal with rather thin walls from which metastases occur at an early stage. DORMANNS mentions that in his material examined post-mortem in Germany, and comprising 1,439 cases of cancer of the oesophagus, there was no dissemination in 21.5 per cent of cases; he does not, however, give the extent of the carcinomatous process in these instances. Incipient growths may have been observed at post-mortem and these casual findings naturally lessen the value of his figures. FLEMING studied 76 of his own and CLAYTON's untreated, post-mortem cases together and found that metastases occurred in 50 per cent if the carcinomatous process was 5.1 cm or less in length and if more extensive only 12 per cent of the patients were free from metastases.

With the development of thoracic surgery, radical treatment of carcinoma of the oesophagus has been more and more employed. It is a method of value, but as very few of the diagnosed cases are operable, other forms of treatment have to be found.

[1] Submitted for publication, Sept. 20, 1950.

The Treatment of Carcinoma of the Oesophagus by Radiotherapy

The majority of the malignant neoplasms in the oesophagus are squamous-cell carcinomas and fairly radio-sensitive. They are generally not of a well differentiated grade and highly malignant. A heavy dose of radiation is required if persisting results are to be obtained. This has proved to be extremely difficult in deep-lying forms of tumour such as carcinoma of the oesophagus.

Radiotherapy is, however, the treatment of choice in these cases. Three different methods may be selected.

1. *Interstitial radium treatment.* This form of therapy cannot be used with sufficient accuracy except in association with surgical interference, as for instance in carcinoma of the fundus of the ventricle which simultaneously affects the lower part of the oesophagus. Even with the aid of an oesophagoscope, the seeds cannot be placed so that the whole area of the tumour is evenly radiated. In many instances the tumour cannot be reached at all. In consequence this method has been little used.

2. *Bougie containing radium tubes.* There are many indications for this method. The area of the tumour can be well radiated without injuring the surrounding healthy tissues, but the remote parts of the tumour are not reached with sufficient intensity. This method is sometimes difficult or even impossible to employ if the lumen is highly constricted and local injury cannot be completely avoided.

In GUISEZ' skilled hands the method has given good results. He describes 270 patients of whom 3 lived 5 years and 8 from 3 to 4 years. No other workers have obtained as good results. ZUPPINGER treated his patients with radium bougies alone, in combination with roentgen rays, or with roentgen alone; with the latter he had the best results.

3. *Roentgen irradiation.* Roentgen treatment is the most favoured therapy in carcinoma oesophagi. A fairly high tension is employed in order to avoid exceeding the skin tolerance dose — 170—200 kV or much more and the so-called cross-fire technique with a number of skin fields is used. Rotation treatment may be considered a modification of this method.

Since 1936 the method for roentgen treatment at the Radiotherapy Institute in Helsingfors has been almost unchanged in cases of carcinoma of the oesophagus. This material, collected from the Institute will be analysed and compared with series from other sources.

The main reason for this investigation being undertaken was the fact that the prognosis in the individual cases seemed to be so unfavourable that the suitability of continuing radiological treatment of tumours of this kind in the overworked clinic was questioned.

The Patients

The series includes 296 cases of carcinoma of the oesophagus and cardia treated from August 1 1936 to March 1 1949. The majority of the patients admitted to the clinic were given the maximum treatment they were able to tolerate. A few were excluded because of widely diffuse changes, especially in the region of the cardia, or because of their poor general condition. All the patients treated were followed up at intervals of 3—6—9 and 12 months.

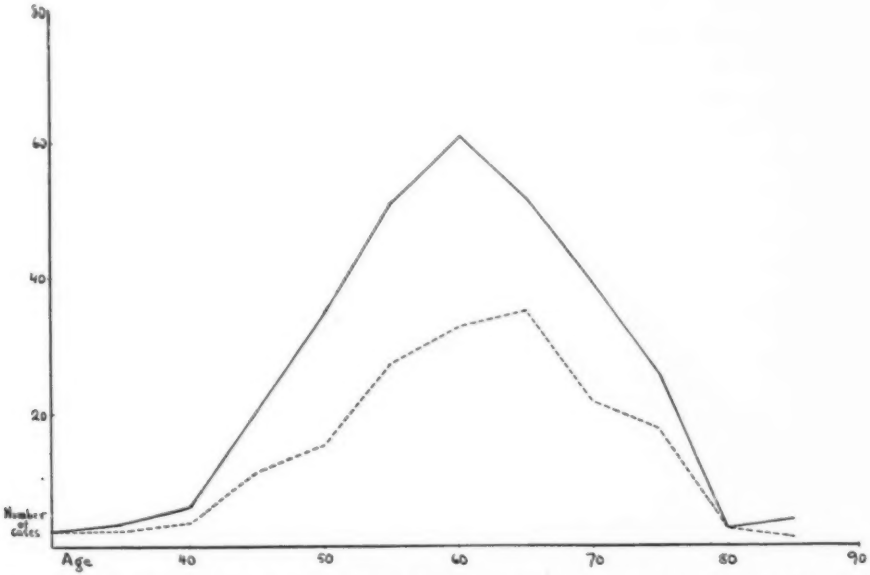

Fig. 1. Age grouping of 296 cases of carcinoma oesophagi. Solid line — all cases. Dotted line — the women.

Age and sex distribution. The 296 patients comprised 129 men and 167 women. The average age for all patients was 57.0 years (56.4 for men and 57.5 for women). This average age is rather low in comparison with that mentioned in the literature. The youngest patient was 29 and the oldest 83, both women. The larger number of patients was found in the age-groups 40 to 50, 50 to 60 and 60 to 70. The age distribution is given in Fig. 1.

Etiology. Sufficient information for evaluating the etiology was lacking in the hospital records. However, 2 patients had taken lye in

childhood, 1 HCl 13 months prior to admission and 1 acetic acid 9 months before coming to the clinic.

Duration of disease before admission. The average period in which symptoms were observed before admission was 4.6 months (4.5 for men and 4.7 for women). The site of the lesion had no bearing upon this — in contrast to the observations of KREBS et al. In their series the time in which symptoms were observed was twice as long for cancers of the cardio-oesophageal junction as for those involving the upper third of the oesophagus. In the present material the opposite was almost the case, *i. e.* 5.3 months for the upper third and 5.2 for the cardia.

The site of the tumours. 12 per cent were found in the upper third, 44 per cent in the middle third, and 39 per cent in the lower third of the oesophagus with 5 per cent in the cardia. Women were in the majority in all groups.

Histology. Oesophagoscopy was performed in 192 of the 296 cases. This was rarely done during the war years due to lack of physicians. Another reason for omitting oesophagoscopy was that the patients' general condition was very poor, or the roentgen findings in combination with other signs were considered sufficient for the diagnosis of carcinoma.

In 24 of the 192 cases tumourous tissue of an undifferentiated variety was detected microscopically. In 4 cases the histological diagnosis of carcinoma was made, but no narrow differentiation was possible. Histologically unverified cases were included in the material due to the past histories, roentgen findings and clinical observations being typical.

One-hundred and twenty-eight of the cases examined histologically had prickle-cell carcinomas, 3 basal-cell carcinomas, 6 adeno-carcinomas and 7 undifferentiated carcinomas. All the adeno-carcinomas were found in the lower third of the oesophagus. Only 2 carcinomas at the cardia were examined histologically and both were found to be prickle-cell carcinomas.

Technique and Dosage

In almost all the cases the treatment was given with 190 kV, 12 mA, 60 cm focus-skin-distance, a 1 mm Cu filter being used. The fields varied, being as a rule 2 vertical anterior fields and 2 posterior fields completed by horisontal fields above or below them. Three vertical anterior and posterior fields were sometimes used, or 4 anterior and posterior fields forming a square. The upper part of the oesophagus was radiated in 3 fields on the anterior part of the neck. The size of the fields was generally 8×10 cm, but sometimes 8×15 cm or other dimensions were used.

The site of the tumour was determined with the aid of roentgen fluoroscopy before starting the treatment. Each field was given 3,000 to 3,500 r, one field being radiated each day, the skin dose varying between

300 and 600 r. The depth dose was calculated by determining the thorax diameter in the direction of the ray and dividing it by 2. The value obtained, worked out according to a table, gave the remaining radiation effect after absorption, expressed in percentage.

The main point of the treatment was to give the patients a tumour dose of at least 5,000 r through fractioned radiation with about 150 r/day. This was done in 45 per cent of the 296 cases. 5,000 r was not considered the maximal dose. 6,000 r was fixed as the maximum and this dose was given to all patients who could tolerate it. 5,000 r is considered the minimum dose in treatment of squamous skin cancer and less should not be given in carcinoma of the oesophagus.

The Reaction During the Treatment

Owing to the small number of beds in the clinic, 80 per cent of the patients were treated as out-patients. This procedure is not satisfactory but better than giving no treatment at all.

As already mentioned, the treatment had to be interrupted in 55 per cent of the cases before the minimum tumour dose of 5,000 r had been reached. It was observed at the beginning of the treatment that some of the patients would not be able to stand a dose of this magnitude and in these cases only a palliative effect was aimed at. Owing to their poor general condition the treatment had to be abandoned in a number of cases which primarily seemed favourable. Some of them had a rise of temperature, a sign of infection associated with a destruction of the tumour or owing to its destruction being too rapid. Very low leucocyte counts were sometimes the reason for interrupting the treatment.

The patients were generally very tired after the treatment but recovered quickly on returning home. The majority who were weighed lost 1 to 3 kg during the treatment. The skin did not show signs of permanent injury in a single case and within a normal period of about 2 months it was soft and smooth again.

Accidents and Complications

In about 10 patients the oesophagus was dilated immediately in association with the treatment or afterwards. Three had haemorrhage immediately after the intubation or within 2 days of it. One patient died. One perforation, probably caused by the intubation, occurred; empyema followed and the patient died on the third day. Intubation of patients with malignant growths of the oesophagus is not to be recommended.

Two patients had haemorrhages during the treatment and at least 4 during a later stage. Oesophago-tracheal fistulae occurred in 4 patients.

Pulmonary changes were revealed roentgenologically at follow-up in about 5 per cent of the cases. They occur, as STRANDQUIST and some other authors mention, in strands or parenchymal patches of different sizes and are generally found in the hilar regions. They are seen 2 to 7 months after the termination of the treatment and metastases may be suspected, but a further control 2 to 3 months later generally reveals their true nature. A fibrous change of the parenchymal patches is then generally observed.

Two patients were subjected to gastrostomy before the institution of treatment. Three gastrostomies were performed during the treatment and 20 at a later date. This operation seems to prolong life but the patient's suffering is prolonged and intensified at the same time. Thus, gastrostomy should only be resorted to in exceptional cases.

Two cases with uncommon complications may be mentioned in this connection.

Case 1. Male: 52 years old. 5 months' history. Towards the end of the treatment and when his difficulty in swallowing had improved his temperature rose and an eczema of an allergic character broke out. He had then been given 4,620 r depth dose over a period of 28 days in 4 fields, the skin dose being 500 r/dose. He grew rapidly weaker and died. At the post-mortem examination no sign was seen of the carcinoma spinocellulare which had been diagnosed histologically. The patient's symptoms had probably been caused by an allergic reaction due to toxins emanating from the tumour.

Case 2. Female: 64 years old. She had had difficult in swallowing for 2 months and was given 400 r on four occasions. Large livid spots appeared on her body and she died. The haemoglobin was 45 Sahli at the beginning of the treatment, and before death only 20. There was probably a sudden exacerbation of her poor blood condition due to the roentgen treatment.

Results

No appreciable percentage of cure can be expected as pointed out by FLEMING and KREBS et al. In a collection of 800 cases, published by 10 different authors, FLEMING (1947) found only 10 cases surviving 5 years.

For patients with carcinoma of the oesophagus, the prognosis is thus *quoad vitam* very poor. The following questions may be asked: A) Can the patient's life be prolonged by roentgen treatment and, if so, for how long? B) Can roentgen treatment alleviate the patient's suffering which is often so intense?

A. The majority of authors (MCGIBBON, FLEMING, ZUPPINGER, ENGELSTAD) consider that the patient may live up to 6 months after commencement of treatment; an average of 5 to 6 months shows that the treatment prolongs life to a certain degree. DORMANNS has only rather

more than 10 per cent of cases treated with radiation in his large series of cases examined post-mortem which may be comparable with a series of untreated cases; in them, the duration of life was only 2.5 months. With rotation radiation KREBS et al. obtained an average duration of life of 8.1 months. Exactly the same figure was obtained in our material (calculated from the beginning of the treatment to the time of death or March 1, 1950).

In most statistics 55 or 65 per cent of the patients die within 6 months. The figure for this category given by KREBS et al. is also correspondingly smaller — 50 per cent. The other figures in our series are: 22 per cent mortality within 3 months, 50 per cent within 6 months and 81 per cent within 1 year. After 2 years only 3 per cent of the patients were still living.

These figures are exactly the same as those given by KREBS et al. except for the last group which comprises only one-third of the corresponding group receiving rotation treatment. In ENGELSTAD's material two-thirds died within 6 months and only 10 per cent were living after one year. In ZUPPINGER's series 65 per cent died within 6 months, 88 per cent within 1 year and 99 per cent within 2 years.

Analysing the relationship between the period of life and the site of the tumour it was found that 3 per cent of the patients with tumours in the upper third of the oesophagus lived 1 year, while the percentage for tumours in the middle or lower third was 17 and 19 respectively and for cardio-carcinoma, 12 per cent.

The very low per cent for carcinoma in the upper third of the oesophagus contrasts sharply with the results of the majority of investigators. Almost without exception their figures show the best results in the treatment of malignant growths in this region. It may be connected with the fact that the treatment of a lesion in the middle and lower thirds of the oesophagus differs from that in the upper third. In the first instance, each depth dose was regularly 225 to 250 r, that is about 100 r more than in the latter; and although the total depth dose did not differ, the fractionization may have affected the results.

Attempts were made to assess the results of the treatment in relationship to the amount of roentgen dosage. The material was divided into 4 groups on the basis of the size of the depth dose.

Group I comprises 28 patients given the maximum dose of 1,500 r. The treatment was terminated owing to complications of various kinds or to a rapid deterioration in the patient's general condition.

Group II comprises 41 patients given 1,500 to 3,000 r. This dose is not considered sufficient, but for various reasons, mainly the general condition of the patient, the treatment was discontinued at this stage.

Group III comprises 88 patients given 3,000 to 5,000 r. As already mentioned, this dose was also considered insufficient, but due to various reasons, the patients were not able to tolerate a heavier dose.

Group IV comprises patients receiving a depth dose of 5,000 r.

The duration of life within Groups I, II, III and IV was 3.9, 5.5, 7.1 and 10.2 months, respectively.

Summing up it may be said that the roentgen treatment of patients with cancer of the oesophagus has a certain life-prolonging effect but not for longer than on an average from four to six months.

Among the 296 cases in this series 2 patients were alive on March 1, 1950, 5 years and 1 month and 5 years and 3 months respectively after treatment and should therefore be described in detail.

Case 1. Female: 45 years old. For 6 months before treatment she had complained of pain on swallowing and during the last month had noticed that the food stuck in the upper part of the oesophagus. She even had difficulty in taking liquid food. General condition fairly good. Oesophagoscopy showed that the upper part of the oesophagus was almost completely blocked by an irregular tumour which was bleeding slightly; the histological diagnosis was carcinoma spinocellulare. She was given roentgen treatment for 24 days to the anterior part of the neck in 4 fields, the skin dose being 7,800 r, and the tumour dose 5,928. At the follow-up, 4 months from the time of commencing treatment, the patient felt well in herself and on oesophagoscopy a certain constriction was observed at the former site of the tumour; the oesophageal wall was however smooth. Her condition has since been unchanged, she swallows without discomfort although she has a feeling of tightness in the throat.

Case 2. Female: 60 years old. For 5 months she had had pain on swallowing food which seemed to stick in the throat. On roentgen examination (Fig. 2) a lesion, 5 cm in length, was found at the level of the arch of the aorta. The outlines were irregular and the pattern of the mucous membrane coarse. On oesophagoscopy it was found that the mucous membrane, at a distance of 29 cm from the upper teeth, was oedematously swollen and bleeding slightly. Tumourous tissue was present at least posteriorly. The histological diagnosis of a specimen was carcinoma spinocellulare with highly atypical cells.

The patient was treated for 32 days through 4 anterior and 4 dorsal fields; 2 vertical fields with a horisontal field above and below being used. 600 r per dose and a total depth dose 6,048 r was given. Three months after completing the treatment the patient felt well and had increased in weight. On roentgen examination a small filling defect was still observed but 2 months later it had disappeared and the roentgen findings were quite normal. Seventeen months after starting her treatment she had put on 2 stone in weight. Three years and a half from the time of starting treatment she had slight pain in her right leg. At 4 years and 10 months she limped slightly and the movements of the right foot were abnormal; neurologists considered this due to nerve changes caused by the irradiation. On follow-up examination 5 years and 3 months after starting treatment she had no trouble on swallowing.

B. In order to assess the symptomatic effect of treatment the patients were grouped into the following categories as suggested by ENGELSTAD:

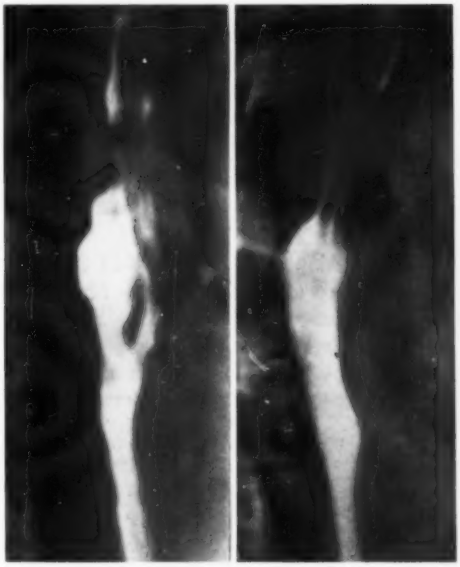

Fig. 2. Case 2. Female: 60 years old. Tumour, 5 cm in length, at the level of the arch of the aorta. The biopsy specimen showed a squamous cell carcinoma. a) Roentgenogram before the treatment. The mucous membrane is coarse and slightly irregular. b) The same patient 4 years after treatment; no changes in the oesophagus.

Fig. 2 a. Fig. 2 b.

free from symptoms, greatly improved, improved, not improved, progressively worse.

The patients were considered free from symptoms if a roentgen examination showed a complete disappearance of the tumour for a shorter or longer period of time. Patients whose difficulty in swallowing had almost completely disappeared and were able to eat solid food were considered greatly improved. Their general condition was consequently much better. Patients in whom there was a marked effect from the treatment but whose improvement was moderate or of very short duration were considered improved.

Table 1

The symptomatic effect of treatment and its relation to the size of the depth dose

	Free of symptoms	Greatly improved	Improved	Not improved	Progressively worse	Total
<1500 r	0	0	2	4	22	28
1500—3000	0	1	14	7	19	41
3000—5000	2	7	32	17	30	88
>5000	15	34	54	18	18	139
Total	17	42	102	46	89	296

The results are seen from the table. The patients were also divided on a depth dose basis.

Thus, 54 per cent of the total number of cases were benefited by the treatment to various degrees. In 30 per cent their condition grew worse, in some cases due directly to the therapy. Actually this group is not large because patients with metastases are included.

The symptomatic effect was small in Groups I and II, as seen from the table, and markedly increased in the groups in which the roentgen dose was larger.

The symptomatic effect in relation to the carcinomatous process was also studied and the results are given in the following table.

Table 2

The symptomatic effect of treatment in relation to the site of the carcinomatous process

	Free of symptoms	Greatly improved	Improved	Not improved	Progressively worse	Total
Upper	2	6	12	6	9	35
Middle	5	19	52	16	38	130
Lower	10	16	31	18	40	115
Cardia	0	1	7	6	2	16

It is seen that treatment of neoplasms in the middle third of the oesophagus gave the best symptomatic effect, while the results in the other groups did not vary very much.

Summing up it may be said that there is a distinct symptomatic effect; more than half the patients benefited in one way or another. This is however highly dependent on whether or not the patient is able to tolerate heavy roentgen treatment. With a depth dose of less than 3,000 r the effect is not good.

Comments

This investigation and figures from some other clinics show that the roentgen treatment of malignant neoplasm in the oesophagus prolongs the duration of life and has a palliative effect. With the present methods however the treatment is not curative.

The cross-fire technique used was practically of the same value as the rotation radiation, described by KREBS et al. (1949). Theoretically the same relationship may be expected. The life-prolonging effect seems to be proportional to the size of the tumour dose. Whether the dose is given in 6 skin fields or in a »belt-like» 360° field seems to be of secondary importance.

In order to trace some special life-prolonging factor all the cases who lived a maximum of 3 months (Group A) were collected and compared with those who lived up to or more than 12 months (Group B). There were 66 and 65 cases in the respective groups. In the first there were 31 men and 35 women and in the second 25 men and 40 women. The age distribution was about the same as in the total cases with the exception that in Group B there were 5 women over 70 but no men. The period during which symptoms were noticed before admission might be expected to be shorter in Group B, *i. e.* that they would have come under treatment at an earlier stage. This was not the case in this series, however. The average time was 4.7 months in Group A and 4.6 months in Group B, *i. e.* exactly the same as in the total cases.

The site of the carcinomatous process greatly affects the period of life. In Group A there was about one-third with carcinoma of the upper third of the oesophagus and cardia, and about one-fourth with malignant growths of the middle or lower thirds. In one-tenth of the cases in Group B the malignant growth was found in the upper third and in one-fourth in the middle and lower thirds of the gullet.

The average increase in the period of life in proportion to the size of the roentgen dose has been mentioned before. The table below shows the number of cases in Groups A and B in per cent within the 4 different depth dose categories.

Table 3

The number of cases per cent who lived at most 3 months, or more than 12 months, in relation to the size of the depth dose

	< 1,500 r	1,500—3,000 r	3,000—5,000 r	> 5,000 r
≦ 3 months.....	16/66—24 %	16/66—24 %	25/66—38 %	9/66—14 %
≧ 12 months.....	1/65—2 %	4/65—6 %	13/65—20 %	47/65—72 %

The number of complications was much larger in Group A. A rise in temperature occurred during the treatment in 9 out of 66 cases while the corresponding figure in Group B was only 2 out of 65. As regards haemorrhage the relation was A/B : 5/0. Gastrostomy was done in 2 and 9 cases respectively and, judging by the results in the individual cases, this procedure has an appreciable effect in prolonging life. The patient's suffering is however at the same time increased.

The sedimentation rate was taken before admission in well over half the number of patients in both groups and the results are given in the table. In Group A there is a larger number of cases with increased rates.

Table 4

The same series as in Table 3 grouped on the basis of the sedimentation rate on admission

SR, mm/1 hour	≦10	11—29	30
≦ 3 months.....	3	12	24
≧12 months.....	9	18	13

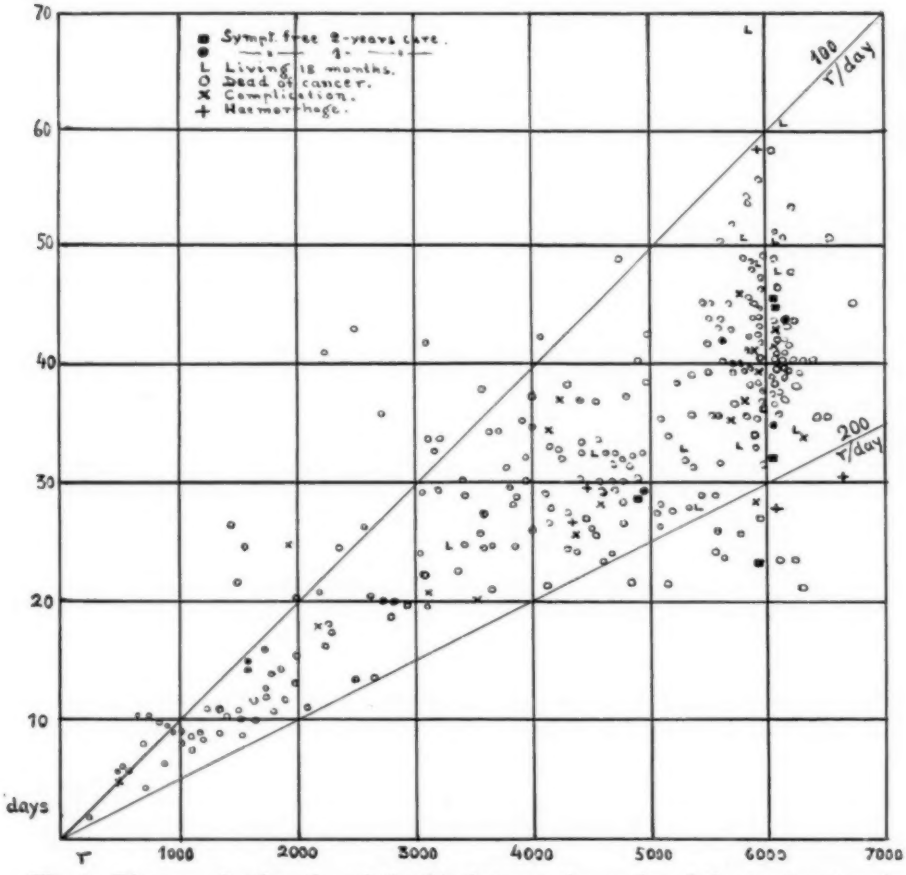

Fig. 3. Diagram showing the relationship between the results of the treatment and the tumour dose in 296 cases of carcinoma oesophagi treated with roentgen. The abscissa is the total tumour dose (in tissue roentgen) and the ordinate the number of treatment days. Each sign in the diagram represents one case.

No sensational evidence is obtained from these comparative statistics. The main point in the treatment of carcinoma of the oesophagus is to select by suitable fractionization a tumour dose of not less than 5,000 r and without, at the same time, causing exacerbation of the patient's general condition.

STRANDQVIST (1941) is already working along these lines. For a close study of the problem a diagram was worked out, similarly to the one in STRANDQVIST's article, in which the ordinate is the number of treatment days and the abscissa the number of r as tumour dose. Each case is marked with a special sign as explained in the text below the figure.

This diagram gives a clear survey of all the cases, the tumour dose in each case and its effect.

The diagram shows that a dose of 100 r/dose will not suffice to prevent recurrence. Almost all cases to be free from recurrence for 1 year or more and particularly 2 years require at least 150 r/dose and a total dose of more than 5,000 r. A large number of cases with haemorrhage or other complications are, however, at the same time included. No sharp line can be drawn between these contradictory signs. With the present methods we have to balance an increased number of complications with the favourable effect. No definite dose with which the effect would be optimal and the risk insignificant, as demanded by STRANDQVIST, can be suggested on the basis of the results of this investigation. It seems as if better results cannot be obtained with the present technique. Supervoltage therapy may give the desired improvement but so far no extensive systematically treated cases have been published to shed light upon the problem.

SUMMARY

Roentgen treatment at about 200 kV of cancer of the oesophagus is a method with an appreciable palliative effect but its curative effect is very small. The result of the treatment seems first of all to be dependent on the tumour dosage and in the second place on the fractionation. Cross-fire and rotation treatment seem to be of nearly equal value. A satisfying palliative effect is not achieved until a depth dose of about 3,000 r has been given. The sooner the patient comes under treatment the better. Metastases occur at an early stage. Treatment is not recommended in cases with high sedimentation rate and in poor general condition.

ZUSAMMENFASSUNG

Die Röntgenbehandlung des Oesophaguscarcinoms mit etwa 200 kV ist eine Behandlungsmethode mit ziemlich grossem palliativem Effekte aber ihre kurative Bedeutung ist äusserst gering. Das Resultat der Behandlung scheint vor allem von der Tumordosis abhängig zu sein, in zweiter Hand von der Fraktionierung. »Cross-fire» und Rotationsbehandlung geben beinahe gleichwertige Resultate. Gute palliative Wirkung erfordert mindestens eine Tumordosis von 3,000 r. Der Fall soll so früh wie

möglich behandelt werden. Metastasen bilden sich früh. Die Behandlung ist nicht bei hoher Blutsenkungsgeschwindigkeit und schlechter allgemeiner Kondition zu rekommendieren.

RÉSUMÉ

Traitement par rayons de roentgen de 200 kV dans les cas de cancer de l'oesophage est une méthode d'un effet palliatif considérable mais n'a que rarement un effet curatif. Le résultat du traitement dépend surtout du dosage du foyer et en second lieu du fractionnement du dosage. »Cross-fire« et traitement rotatoire semblent être de valeur égale. Un effet palliatif effectif n'est obtenu qu'avec un dosage de tumeur de 3,000 r. Le malade doit être traité aussitôt que possible. Des métastases se developpent rapidement. Le traitement n'est pas recommandé en cas d'une sédimentation baissée et d'une mauvaise condition générale.

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FROM THE PHOTO-FLUOROGRAPHY SECTION OF THE ROYAL MEDICAL BOARD, STOCKHOLM, SWEDEN (DIRECTOR: MED. DR. ARNE NELSON)

IMPROVEMENTS IN PHOTO-FLUOROGRAPHIC TECHNIQUE[1]

by

Arne Nelson

In order to make the most effective use of the diagnostic possibilities of photo-fluorographic mass examinations, it is necessary to have physicians who are experienced in examining the photo-fluorograms, which must be of a good and even quality.

In this paper I shall only refer to the possibilities of obtaining images of even and good quality. I am basing my remarks primarily on experiences in Sweden, where photo-fluorographic examinations have been carried out on a fairly large scale since 1941. A central state organization, the Photo-Fluorography Section of the Royal Medical Board, has been supervising the examination of the whole population since 1946. My own observations are based on approximately two and a half million examinations.

While these examinations have been going on, considerable technical improvements have been made. Particularly during the 4 years that the central organization has been at work, continual improvements have taken place. These have been due both to experience and to the good co-operation of the roentgen firms. In addition, new types of apparatus, including the latest technical imrpovements, have been manufactured. (Fig. 1.)

The first type of apparatus used for photo-fluorography was most often the ordinary mobile military roentgen apparatus, to which had been added a special stand for photo-fluorography. These were either a half-wave or four valve apparatus and when used for photo-fluorography were exposed to enormous strain, owing to the great frequencies of exposures at maximum capacity. At first only 35 mm films and lenses with an aperture f 1.5 were used.

In order to attain greater diagnostic accuracy, the 80 mm film was adopted. The camera first available had only a lens with an aperture

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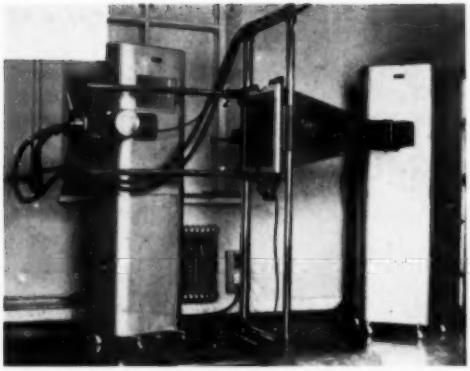

Fig. 1. Photo-fluorographic stand used with mobile military roentgen apparatus.

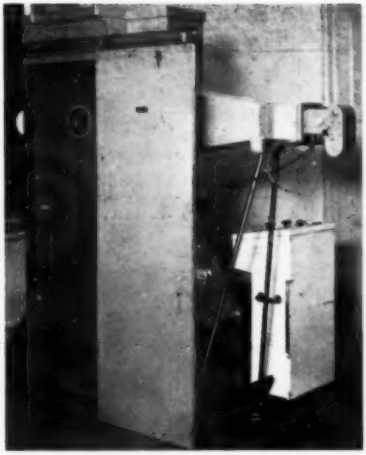

Fig. 2. Condenser apparatus for photo-fluorography with protecting chamber open.

f 2, which demanded an increased capacity of the roentgen generators. Consequently a higher output four valve apparatus was used with rotating anode tubes. In spite of this the exposure times were rather long, varying between 0.5 and 1.5 seconds. When mobile it was often difficult to find mains of satisfactory capacity to which the apparatus could be connected.

In order to get more even exposures and shorter times condenser apparatus were consequently adopted; it gave good results even with unsatisfactory mains. Improved lenses with aperture f 1.5 could be obtained even for 80 mm film. Moreover, grids and fluorescent screens were improved so that the exposure could be still further reduced. As we know, it is difficult to obtain exact and effective exposure times when using condenser apparatus with direct discharge through the tube, though it should be possible to select them to within about 0.1 of a second. A type of apparatus was then produced, which, from a photographic and technical viewpoint, gave satisfactory results.

However, another problem now arose. It was found that the technical staff were getting comparatively large doses of roentgen rays. This was due primarily to scattered radiation from the patient. For instance, in 1946 a clerk developed leucopenia, anemia and bone-marrow damage. Others developed blood changes of a less serious nature. As a result the Swedish authorities tightened up the regulations for protection against exposure to radiation so that the tolerance dose was reduced from 0.25 to 0.01 r per day. In order to overcome this problem we concluded,

Fig. 3. Exterior of bus for photo-fluorography.

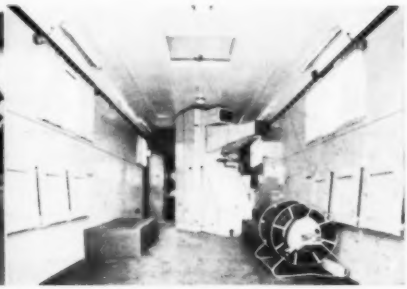

Fig. 4. Interior of bus for photo-fluorography.

in co-operation with the Institution of Radiophysics in Stockholm, that the only way to get complete protection against radiation was to screen off the scattered radiation as near as possible to the patient. (Fig. 2.) In practice it meant that during the exposure he or she was completely enclosed in a protecting chamber. We were, therefore, not restricted to a maximum number of examinations per day.

An apparatus has now been produced, which takes photo-fluorograms of good quality, works well even on unsatisfactory mains and is adequately protected. This type of apparatus is heavy, however, weighing about 1,500 kg, *i. e.*, 3,000 lbs. and is difficult to install.

As the chances in Sweden of there being a greater attendance at the examination if there are suitable premises available we make use of transport vans for the greater part of our apparatus.

Condensers and high-tension generators must be fixed in the vans on account of their weight. The actual examination stand with the roentgen tube, which is connected to the van, however, is placed in the examination room.

For technical reasons the cable must not be more than 15 meters long, which means that the examinations cannot be carried out in all types of premises. (Fig. 3.)

A few apparatuses have been installed in buses in which examinations can take place, but they are mainly used in thinly populated districts. (Fig. 4.)

The reliability was naturally also affected by the comparatively complicated construction, which included sensitive parts, such as rotating anode tubes, valves, high tension condensers and cables.

Experience has shown that if we wish to have as much support as possible from the general public in these mass examinations, the photo-fluorographic teams must be extremely mobile. Incidentally it may be worthy of note to say that in Sweden on an average *more than 90 %*

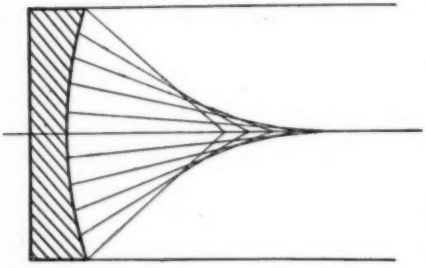

Fig. 5. Spherical aberration in a concave spherical mirror.

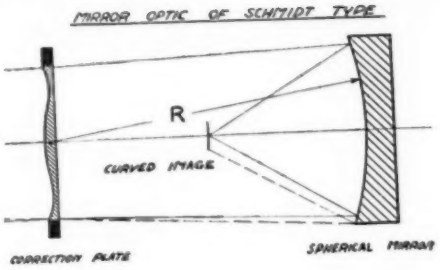

Fig. 6. Section of Schmidt optics.

of those invited have come to be examined, in spite of examinations not being compulsory.

We therefore endeavoured to produce equipment that could be easily transported, was not bulky, did not weigh very much and could be fitted together by two men. The apparatus would naturally have to be reliable and the quality of the images, of the highest standard.

It is primarily the extremely luminous optical mirror system that has made it possible to fulfil these desires.

The first camera for photo-fluorography with the mirror system was constructed by HELM and CHRISTIANSEN in Denmark in 1942. This camera was built according to the system of BERNHARD SCHMIDT, the astronomer, and had a concave spherical mirror and a non-spherical lens or correction plate. To begin with, the camera was intended for 35 mm film, and by 1945 and 1946 a small number of such cameras were in use in Denmark. Later Helm also constructed a camera for 70 mm films with optics of f 0.68 aperture.

Mirror systems are considerably more luminous than lens systems. An ordinary concave spherical mirror causes spherical aberration (fig. 5), as the focus of the peripheral rays is nearer the mirror than the central rays. The chromatic aberration, on the other hand, can be ignored. Schmidt corrected the spherical aberration by using a non-spherical lens (fig. 6), which was located in the centre of the curvature of the mirror.

In this mirror system the image is curved with the convexity facing the mirror, and it has the same centre for the radius of the curvature as the mirror. Hence the film must be curved in order to avoid unsharpness. This is done by pressing the film between a concave frame and a convex plate which have the same curvature as the image.

The most important advantage to be gained from the Schmidt optics is the great luminosity due to the favourable relative aperture and the minimal loss of light by reflection. With the Schmidt camera in use

in Sweden and made by Helm, the roentgen capacity required is only 1/8 of that necessary for a lens having an aperture of f 1.5.

Moreover the Schmidt camera has a comparatively high definition, not only in the centre of the image but also in the periphery. According to measurements carried out by the Bureau of Standards, the resolving power is uniformly 16 lines per mm over the entire field.

The Schmidt system requires a relatively long distance between the grid and the camera, which is naturally a disadvantage. It has been possible to solve this problem, however, by introducing into the optical system a plane mirror at an angle of 45°, and to place the camera tunnel vertically. In practice this mirror causes a loss of light of only, at the most, 10 %.

It is naturally essential to adjust the optical system with the greatest accuracy so as to get an optimal sharpness of the image. For instance, a change in the distance between the plane of the film and the spherical mirror need not be more than 0.04 mm for it to cause unsharpness. But with the methods now in use, all necessary corrections can be made with accuracy. A sceptical attitude towards mirror systems may arise if pictures should be produced with apparatuses which have not been satisfactorily adjusted.

There is a great interest in mirror optic systems all over the world. Bouwers has constructed a type of mirror system differing from Schmidt's, inasmuch as there is a spherical correction plate. The film is curved in one plane and the fluorescent screen in another in order to compensate the curved image. The firm of Philips of Eindhoven has also constructed a mirror system camera based on the Schmidt system. The correction plates, which are also intended for television purposes, are moulded from gelatin on a glass foundation. In order to be able to make use of this system for photo-fluorographic purposes as well, they have changed to an entirely new film size, *i. e.*, 45 mm which makes it almost necessary to project the images when examining them.

As luminous mirror systems require only 1/8 of the roentgen energy

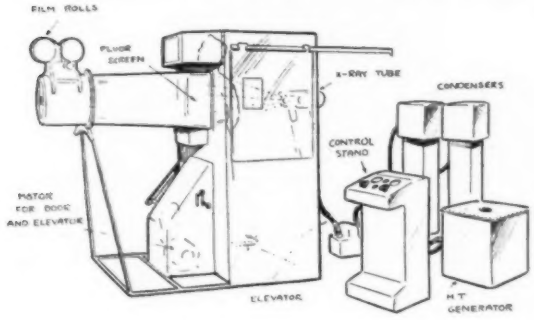

Fig. 7. Condenser apparatus with Schmidt optics.

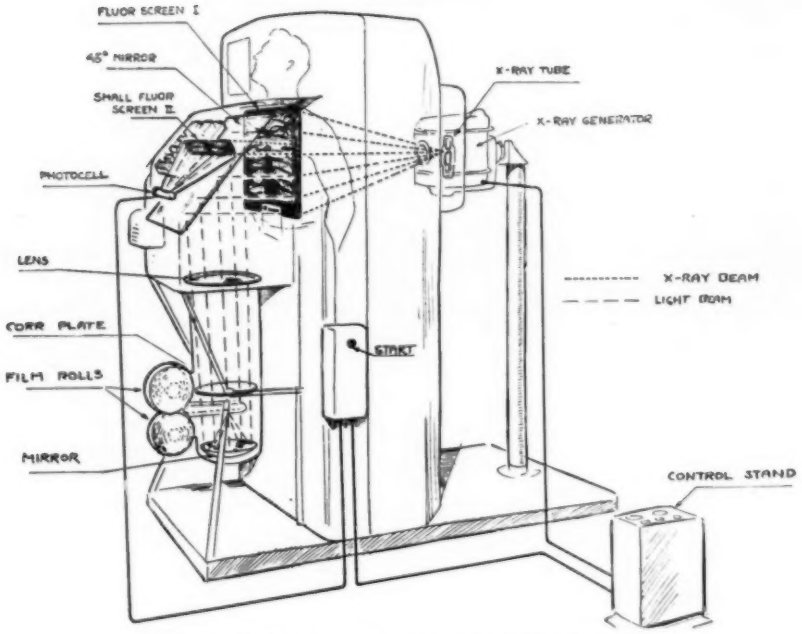

Fig. 8. Half-wave apparatus with Schmidt optics.

compared with lenses of f 1.5 aperture, it is possible to make use of a roentgen apparatus with a considerably lower capacity. (Fig. 7.) A condenser apparatus of low capacity may then be used, with some saving of weight, although the apparatus is comparatively heavy and complicated. It is practically impossible to make use of a phototimer with the particular apparatus.

Thorough tests have shown that with a half-wave apparatus used with the mirror system and with a maximal capacity as low as 85 kVp at 30 mA, shorter exposure times have been obtained than with a 200 mA, four valve apparatus used with the same system. (Fig. 8.)

The great advantages of the half-wave apparatus are its extreme simplicity in construction, its reliability, and its amazingly high capacity compared with its weight. This is particularly the case when it is constructed as a so-called one tank apparatus, that is to say, when both valves and cables are dispensed with. This is of great importance when it comes to mobile units.

A roentgen apparatus of low capacity can produce satisfactory results both with mains having comparatively high resistance, and with generators of low capacity, and, therefore, less weight.

Fig. 9. Fully protected equipment with Schmidt camera with protecting chamber open.

Fig. 10. Same apparatus as in fig. 9 dismounted for transport.

The reduced radiation output during photo-fluorographic examinations with mirror systems makes protection against radiation easier, with the result that the weight can be further reduced. (Fig. 9.) In photo-fluorographic apparatuses, where patients are completely enclosed during the exposure, the simplest way is to have the roentgen tube and camera tunnel fixed, and for the patient to be raised and lowered by means of a comparatively heavy motordriven lift. A later development is the NOSCHIS device which is considerably lighter as it eliminates the motor. With the device the platform is lowered by the patient's own weight, and when unloaded the platform is raised by a counter weight. (Fig. 10.)

This apparatus, which we now consider is the best answer to all the requirements mentioned, only requires floor space of about 70×135 cm, and weighs only 450 kg, *i. e.*, 900 lbs., the heaviest unit weighing approximately 80 kg, *i. e.*, 160 lbs. Two men can install the apparatus without tools.

We did not use radiographic exposure meters when working with condenser apparatus, but after adopting the half-wave type of apparatus, we began to use a phototimer of practically the same type as MORGAN's.

In principle it consists of a photo cell, in which is produced a current in direct proportion to the light intensity on the fluorescent screen. This current is used to regulate the exposure time, so that the images will always be of an even *density*.

The *quality* of the image will also be more uniform due to the phototimer. This is best seen in examinations carried out by mobile units, when the apparatus must often be connected to mains of varying output. Nevertheless we are still hoping for further technical improvements.

The exposure meter constructed by FRANKE, which is based on an ionization chamber, may prove to be an important link in development, though as yet we have not been in a position to test it.

However good the technical apparatus may be, the best use cannot be made of it unless it is in the hands of a fully qualified personnel and the quality of the image is frequently checked. In Sweden we have an organization for the general photo-fluorographic examination of the population. The characteristic feature of this institution is that it is both decentralized and centralized. The work is decentralized inasmuch as the preparatory work of the organization and propaganda, the local preliminary work and the summoning of persons to be examined lie entirely in the hands of central and local committees appointed by the county councils, which correspond to Health Districts. In addition, there are one or more central tuberculosis dispensaries in every district, and these are responsible for the control of the cases that photo-fluorography has shown to need continued radiological and clinical examination.

We have, on the other hand, a developed centralization of all work in connection with the preparation of the actual photo-fluorographic image, from the time of exposure until it reaches the central tuberculosis dispensary after having been interpreted and reported. By means of this technical centralization we get a far more qualified control over and service from the apparatus as well as over the work of the technicians in the field. Central processing, in practice completely eliminates the factors of errors that may readily arise when the teams themselves do the developing on a small scale with the consequent deterioration in the quality of the image. The advantage of this central development can only be achieved if there is a specially fitted darkroom and an experienced staff. It also allows comparison of the quality of the images from the respective teams, and in this manner it is possible to make improvements; the medical examination of the film can also be improved and standardized. In the first place considerable experience can be gained by examining a large number of films, and secondly, it is possible to consult colleagues in other particular spheres.

The following measures are of importance in connection with this technical control. Every week the technicians send in a special roentgen-technical report of the exposure data and possible errors due to the apparatus, by which means some idea can be obtained of the defects of the equipment.

As a further control the technicians are compelled to take and develop test films every time the apparatus is moved or at any rate twice a week. These films are then sent in to the Central Photo-Fluorography Section with technical data. In addition, it is the duty of the doctors

continually to keep the personnel informed on questions of technical errors and defects. Every week the medical director discusses with his colleagues and available technical personnel, the technical quality of the results from the various teams. By these means there has been considerable improvements in the quality of the photo-fluorograms.

As we know, photo-fluorographic examination on a large scale has so far only been developed in countries with a comparatively good road system, where it has been possible to use the heavy and inconvenient apparatus initially at hand. Nevertheless, we must count on a rapid increase in photo-fluorographic examinations, and development must not be hampered by transport difficulties. We must have simple and light apparatuses that can be easily transported in small cars, boats or even helicopters. The improvement in the photo-fluorographic apparatus that is now taking place in Sweden may prove to be a step in this direction whilst maintaining or improving the resultant high standard.

SUMMARY

The author emphasizes the importance of high image quality in photo-fluorographic surveys and describes the improvements in photo-fluorographic technique, including mirror optics, phototimers, brighter fluoroscopic screens, better grids, complete protection against scattered radiation, and the technical control measures, which result from experience gained in Sweden, where photo-fluorographic surveys have been carried out on a large scale since 1941, and where a central state organisation has been directing a survey of the total population since 1946.

ZUSAMMENFASSUNG

Der Verfasser unterstreicht die Wichtigkeit hoher Bildqualität bei Schirmbilduntersuchungen. Er beschreibt die Verbesserungen der Schirmbildtechnik, die Spiegeloptik, Belichtungsmesser, bessere Durchleuchtungsschirme und Sekundärstrahlenblende und vollständigen Strahlenschutz umfasst, sowie die technischen Kontrollmassnahmen, die auf Grund der Erfahrungen in Schweden zur Anwendung kamen, wo man die Schirmbilduntersuchungen in grossem Massstab seit 1941 vornimmt, und wo eine staatliche zentrale Organisation eine Untersuchung der ganzen Bevölkerung leitet.

RÉSUMÉ

L'auteur souligne l'importance d'obtenir des images d'excellente qualité dans les examens radiophotographiques et décrit les améliorations de la technique radiophotographique, améliorations portant sur l'optique de miroir, la minuterie, la qualité des écrans fluorescents et des diaphragmes secondaires, la protection contre le danger des Rayons Roentgen, qui doit être parfaite, ainsi que les mesures techniques de contrôle, tous perfectionnements qui ont été réalisés sur la base des expériences faites en Suède, où la radiophotographie a été pratiquée sur une large échelle depuis 1941, et où une organisation gouvernementale centralisée préside à l'examen de toute la population depuis 1946.

Resolution Adopted on Classifications of Cervical Cancer

Whereas the so-called League of Nations' Classification of Carcinoma of the Uterine Cervix is now in common use in many countries, but is not used exclusively in the United States of America, it is desirable that this classification, or an acceptable modification thereof, be adopted universally in order to reach a common ground of understanding. Therefore, a Committee of duly appointed representatives of the

Section of Obstetrics and Gynecology of the American Medical Association, the American Association of Obstetricians, Gynecologists, and Abdominal Surgeons, and the American Gynecological Society,

meeting in session with the *Editorial Committee of the Annual Report on the Results of Radiotherapy in Carcinoma of the Uterine Cervix* on the occasion of the International and Fourth American Congress on Obstetrics and Gynecology at New York City on May 14—19, 1950, has agreed to propose the following modification of the classification adopted by the Health Organization of the League of Nations in 1937:

Stage 0

Carcinoma *in situ* — also known as pre-invasive carcinoma, intra-epithelial carcinoma and similar conditions.

Stage I

The carcinoma is strictly confined to the cervix.

Stage II

The carcinoma extends beyond the cervix, but has not reached the pelvic wall.
The carcinoma involves the vagina, but not the lower third.

Stage III

The carcinoma has reached the pelvic wall. (On rectal examination no »cancer-free» space is found between the tumor and the pelvic wall.)
The carcinoma involves the lower third of the vagina.

Stage IV

The carcinoma involves the bladder or the rectum, or both, or has extended beyond the limits previously described.

Be it resolved that this Classification be termed the International Classification of the Stages of Carcinoma of the Uterine Cervix, and that all organizations concerned with the problem on hand be approached to consider its adoption.

COMMITTEE

(Section of Obstetrics and Gynecology, American Medical Association)
Roy Calkins, M. D., Walter Dannreuther, M. D., William Mengert, M. D.

(American Gynecological Society)
Herbert Schmitz, M. D., Ludwig Emge, M. D., William P. Healy, M. D.

(American Association of Obstetricians, Gynecologists, and Abdominal Surgeons)
Bayard Carter, M. D., Robert Faulkner, M. D., James Corscaden, M. D.

(Editorial Committee, Annual Report of Results of Radiotherapy in Carcinoma of the Uterine Cervix)
James Heyman, M. D., Malcolm Donaldson, M. D., Joe V. Meigs, M. D.

Preliminary Programme

of

THE SEVENTEENTH CONGRESS IN AARHUS

12th—14th June, 1951

Tuesday, June 12th: Meeting of the Board of the Northern Association for Medical Radiology at 3 p. m. In the evening reception at the Town Hall; the members of the Congress will be the guests of the Danish Society of Radiology and the City of Aarhus (Morning dress).

Wednesday, June 13th: Opening ceremony in the Great Hall (Aula) of the University. — Scientific meetings.

Thursday, June 14th: Scientific meetings. Closing session. In the evening Congress Dinner (Evening dress).

A special programme for the ladies is being prepared and will be published later.

(1) *Registration for attending the Congress:* The invitation card must be returned before May 1st. Congress fee: 30 Danish kroner.

(2) *Registration of communications:* Titles of papers to be read before the Congress must be submitted not later than May 1st, but for the sake of planning the programme we should be grateful to receive such notification as soon as possible. The duration of each communication will be limited to 15 minutes.

A lantern (for 5×5 cm and 8×8 cm slides), an epidiascope (15×15 cm approx.), an apparatus for direct projection of roentgen films, and a 16 mm film projector are available.

The following subjects will be treated in detailed lectures:

Planigraphy (Rolf Weyde, Oslo).

Roentgen Examination of the Soft Tissues of the Extremities (Arne Frantzell, Upsala).

Chemotherapy of Cancer (Jørgen Bichel, Aarhus).

The duration of each of these lectures will be approximately 45 minutes.

(3) *Hotel accommodation* may be arranged through the Hotel Bureau, Raadhuset, Aarhus by returning the card sent to the members not later than May 1st.

We look forward to a large gathering at the Congress and extend to our colleagues a cordial welcome to Aarhus.

Carl Krebs,
President

Carl Sandström,
Secretary-General,
St. Eriks Sjukhus, Stockholm

Olaf Brøbeck,
Secretary,
Radiumstationen, Aarhus

P.S.: The above invitation has been sent to all members of the Scandinavian Radiological Societies. Those wishing to attend the Congress without being members of these societies are requested to communicate with the Secretary of the Congress, Dr. Olaf Brøbeck, Radiumstationen, Aarhus, from whom registration forms for attending the Congress, for notification of papers, and for hotel accommodation may be secured.